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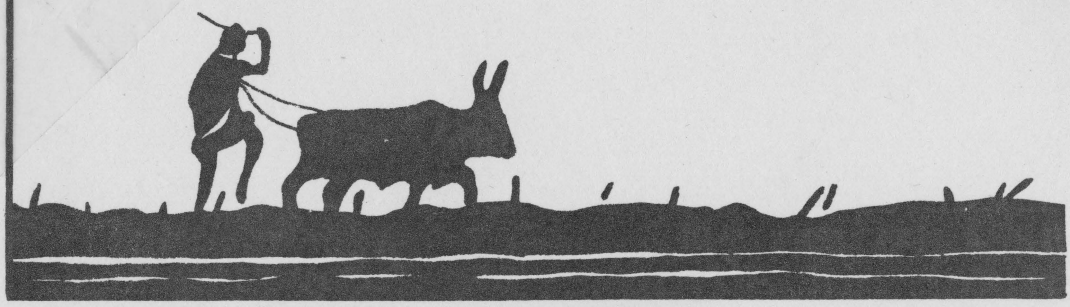
FARMING SYSTEMS RESEARCH & EXTENSION: MANAGEMENT AND METHODOLOGY

Edited by
Cornelia Butler Flora & Martha Tomecek

Paper No. 11 August, 1986

FARMING SYSTEMS RESEARCH PAPER SERIES



RESOURCES ON DEVELOPING COUNTRIES

KANSAS STATE UNIVERSITY
MANHATTAN, KANSAS 66506 U.S.A.

FARMING SYSTEMS RESEARCH & EXTENSION: MANAGEMENT AND METHODOLOGY

Edited by
Cornelia Butler Flora & Martha Tomecek

Paper No. 11 August, 1986

FARMING SYSTEMS RESEARCH PAPER SERIES

Kansas State University's Farming Systems Research (FSR) Paper Series is supported by the U.S. Agency for International Development Title XII Program Support Grant. The goal of the Program Support Grant is to increase the University's ability to implement Title XII agricultural and nutritional development assistance programs in less-developed countries. This series is maintained by the FSR Program Associates -- a multidisciplinary team of professors who are aiming their activities at applied research on farming from a systems perspective.

The purpose of the FSR Paper Series is to disseminate information on FSR. Publication categories include updated bibliographies from KSU's FSR data base; proceedings from KSU's annual Farming Systems Symposium; selected papers presented in KSU's FSR Seminar Series; selected papers prepared by KSU's Programs Associates.

Copies of these papers may be obtained from the Distribution Center, Umberger Hall, Kansas State University, Manhattan, Kansas 66506. There will be a charge for selected papers and multiple copies to help defray cost of printing.

Vernon C. Larson
Director

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FIFTH ANNUAL FARMING SYSTEMS RESEARCH AND EXTENSION SYMPOSIUM

OCTOBER 13 - 16, 1985

KANSAS STATE UNIVERSITY, MANHATTAN, KANSAS

FARMING SYSTEMS RESEARCH AND EXTENSION: MANAGEMENT AND METHODOLOGY

CO-SPONSORED BY: THE OFFICE OF INTERNATIONAL AGRICULTURAL PROGRAMS, USAID TITLE XII STRENGTHENING GRANT, KANSAS STATE UNIVERSITY AND THE FARMING SYSTEMS SUPPORT PROJECT, USAID

SYMPOSIUM PLANNING COMMITTEE

Cornelia Butler Flora, Co-Chair
William J. Jorns, Co-Chair

Wayne Geyer
Duane Nellis
Charles Bussing
L. V. Withee

SUNDAY, OCTOBER 13

PRE-SYMPOSIUM WORKSHOPS

3:00- 5:00 pm - Introduction to FSR/E - Room 212, K-State Union
John Caldwell

1:00- 5:00 pm - On-Farm Trials - Big Eight Room, K-State Union
Randy Barker

5:00- 7:00 pm - Communications: Management and Methodology - Ramada Inn
Jim Bemis & Gretchen Graham

REGISTRATION

3:00- 8:00 pm - Registration - University Ramada Inn

RECEPTION

8:00- 9:30 pm - No-Host Reception - Bockers II, University Ramada Inn

MONDAY, OCTOBER 14

7:30-12:00 pm	Registration: 2nd Floor, K-State Union
8:00- 6:00 pm	Book Display: Cottonwood Room, K-State Union
8:00- 6:00 pm	AGRICOLA Online Demonstration: Cottonwood Rm. K-State Union, J. T. MacLean, NAL

8:45- 9:00 am - WELCOME: Little Theatre
Walter Woods, Dean of Agriculture, Kansas State University

9:00- 9:45 am - MANAGEMENT AND METHODOLOGY: Little Theatre
Presiding: Vernon Larson, Director, International Agricultural Programs, Kansas State University

9:00- 9:45 - "Agricultural Research and Extension in Francophone West Africa: The Senegal Experience"
R. Bingen & J. Faye

9:45-10:00 - Discussant: Donald Pickering

10:00-10:30 am - Break: 2nd Floor Concourse

10:30-12:00 pm - MANAGEMENT AND METHODOLOGY (Cont'd): Little Theatre
Presiding: Gretchen Graham

10:30-11:15 - "Factors Influencing Recommendation Domain Boundaries of the Farming System and Levels of Agricultural Development in Lusaka Province, Zambia"
C. Njobvu

11:15-12:00 - "From Farming Systems Research Methodology to Functional Systematic Routine Management: FSR Methodology to FSR Management in the CARDI FSR/D Project"
R. Hart & M. Ingle

12:00- 1:30 pm - Lunch: Main Ballroom
Presiding: Jim Jorns
Address: "Reaching Female Farmers through Male Extension Workers"
A. Spring

1:30- 3:00 pm - CONCURRENT SESSIONS: DIAGNOSTIC: Little Theatre
MANAGEMENT ISSUES IN INSTITUTIONALIZATION: Big Eight Room

DIAGNOSTIC: Little Theatre
Presiding: Charles Bussing

1:30- 2:00 - "Evaluating a Method for Defining Recommendation Domains: A Case Study from Kenya"
S. Franzel

2:00- 2:30 - "Recommendation Domains Reconsidered"
T. Cornick & A. Alberti

2:30- 3:00 - "The "Diagnostic Phase" of Farming Systems Research in Agricultural Planning: A Case Study from Indonesia"
C. Bartlett & S. Arifin

3:00- 3:30 pm - Break: 2nd Floor Concourse

3:30- 5:30 pm - DIAGNOSTIC (Cont'd): Little Theatre
Presiding: Charles Bussing

3:30- 4:00 - "A Classification of Farming Systems Preliminary to an Extension Program"
A. Capillon

4:00- 4:30 - "Exploring New Information into Decisions about On-Farm Trials: Experience from Two USAID Funded Farming Systems Projects in the Philippines"
J. Beebe

4:30- 5:30 - Discussant: German Escobar

MANAGEMENT ISSUES IN INSTITUTIONALIZATION: Big Eight Room
Presiding: Janet Benson

1:30- 2:00 - "Shifting Towards a More Comprehensive Farming System Approach in Bangladesh"
M. Z. Abedin & R. N. Mallick

2:00- 2:30 - "The Evolution of FSR at the National Institute of Agronomic Research in Niger (West Africa)"
L. Samba, G. Numa, M. Goube, C. Reddy, S. Swinton & R. Deuson

2:30- 3:00 - "Comparative Extension: The CES, TES, T and V, and FSR/E"
W. Rivera

3:00- 3:30 pm - Break: 2nd Floor Concourse

3:30- 5:30 pm - MANAGEMENT ISSUES (Cont'd): Big Eight Room
Presiding: Gary Naughton

3:30- 4:00 - "Management Issues in Linking Research and Extension"
T. King

4:00- 4:30 - "Strategies of Diversification in Guatemala"
J. L. Monterroso

4:30- 5:00 - Discussant: R. Bernsten

7:30- 9:00 pm - PANEL DISCUSSION: Collaborative Research Support Program & FSR
Presiding: Cornelia Flora
Pat Barnes-McConnell, Bean/Cowpea CRSP
L. V. Withee, INTSORMIL (Sorghum/Millet) CRSP
C. B. McCants, Tropical Soils CRSP
M. Nolan, Small Ruminant CRSP

TUESDAY, OCTOBER 15

8:00- 6:00 pm	Book Display: Cottonwood Room, K-State Union
8:00- 6:00 pm	AGRICOLA Online Demonstration: Cottonwood Rm. K-State Union, J. T. MacLean, NAL

8:00- 9:30 am - POSTER SESSION I: K, S & U Ballrooms

1 - "Sondeo Observation & Training Materials" (Room 204)
H. McArthur & V. Sigman

2 - "An Experience of Participatory Research with Colombian Peasant Organizations"
J. Alvarez

3 - "Trends of Liberian Farming Systems in Middle-Level Training Curricula"
A. Bartosik

4 - "Learning about Systems Approaches to Agriculture"
R. Bawden

5 - "The Use of Remote Sensing Techniques in Farming Systems Research: Reconnaissance and Evaluation"
C. Hutchinson & M. Lynham

6 - "Farming Systems in Areas of Farmer-Herder Interaction in Africa: Toward an Appropriate Model for Investigation"
M. Diop, G. Livington & D. Campbell

7 - "Training Strategy for Middle Level Technicians in Farming Systems Research and Extension"
S. S. Cheema & J. N. Kaul

8 - "Identification and Characterization of Agricultural Enterprises"
M. Elena

9 - "Introduction of Animal Transportation in the Nuba Mountains, Sudan"
T. Gillard-Byers

10 - "Simple-to-Use ANOVA Programs Using Supercalc 3"
J. Hammerton

11 - "Farming Systems Research at IITA"
N. Hahn

12 - "Agricultural Equipment as a Constraint in Farming Systems"
R. Kaul

13 - "Draught Animal Management for Early Ploughing"
B. Koch, S. Masikara, G. Heinrich & W. Matlho

14 - "Intra-Household Variation in Agricultural Production Characteristics in North-Chipata District (Zambia): Implications for Projects in a Changing Environment"
S. Kumar

15 - "Strategies for Integrating Environmental Assessment into Farming Systems Reconnaissance Endeavors"
G. Matzke, J. Pease & R. Vincent

16 - "Transfer of Engineering Technologies in Prevailing Farming Systems in India"
V. Mittal

17 - "Potential of FSR/E for Small Farms in Developed Economies"
W. Musser, S. Miller & D. Acker

18 - "Systems Approach to Data Analysis: One Component of the Development of Alternative Research Strategies"
D. Davis, L. Duckstein, M. Fogel & M. Norvelle

19 - "Participatory Research with Peasants: A Strategy for Rural Development: The Case of Duitama, Boyaca, Colombia"
E. Perez

20 - "International Potato Center: Small Farmer Participation in Research"
R. Zachmann

21 - "Home Technologies for Food Preservation"
S. Thompson

22 - "Five Years of Farming Systems Research in Southern Peru"
M. Tapia

9:30-10:00 am - Break: 2nd Floor Concourse

10:00-12:00 pm - CONCURRENT SESSIONS: FSR DESIGN STRATEGIES: Little Theatre
MANAGEMENT: Big Eight Room
FARMER PARTICIPATION: Room 212

FSR DESIGN STRATEGIES: Little Theatre
Presiding: Gretchen Graham

10:00-10:30 - "Gestion et Methodologie"
S. Hamidou

10:30-11:00 - "Farming Systems Research Techniques: Interdisciplinary Interaction and Recurrent Diagnosis"
D. Galt

11:00-11:30 - "The Temporal Dimension in Farming Systems Research: The Importance of Maintaining Flexibility and Resiliency under Conditions of Uncertainty"
L. Lev & D. Campbell

11:30-12:00 - Discussant: M. Gaudrau

TUESDAY, OCTOBER 15

MANAGEMENT: Big Eight Room
Presiding: Duane Nellis

10:00-10:30 - "Strategies for Planning, Managing & Implementing System Research in the Humid Tropics"
A. Agboola

10:30-11:00 - "Recent Trends in FSR/E in Indonesia"
A. Syarifuddin K.

11:00-11:30 - "Linking Government Line Agencies and Educational Institutions in the Implementation of Farming Systems Projects"
M. Villanueva

11:30-12:00 - Discussant: Constance McCorkle

FARMER PARTICIPATION: Room 212
Workshop: H. McArthur & V. Sigman

12:00- 1:30 pm - Lunch: Main Ballroom

1:30- 3:00 pm - POSTER SESSION II: K, S & U Ballrooms

1 - "Low Adoption of Short Kaura Over Farafara Variety of Sorghum Among Northern Nigerian Farmers: An Engineering View Point"
J. P. Mihal

2 - "The Lorena Stove: An Energy-Efficient, Economical and Safe Source of Heat"
S. Thompson

3 - "Developing Farming Systems for Small Farmers in Paraiba State, Northeast Brazil"
E. Zaffaroni, H. Barros & V. Araujo

4 - "The University and FSR: An Integrated Tropical Farm Homestead Model"
D. Riley

5 - "Cost Analysis of Prevailing Systems of Harvesting and Threshing of Wheat in Northern India"
V. K. Mittal

6 - "Achievements and Limitations of the Participation of Peasant Communities and Institutional Functionaries in the Design and Execution of Rural Development"
G. Rudas

7 - "Integrated Study of Crop and Livestock Systems in Haryana State (India)"
B. K. Singh & H. C. Sharma

8 - "Spatial Analysis and Inter-Disciplinary Collaboration in Farming Systems Research"
F. Sowers

9 - "Farming Systems Research: Human Methods vs Managerial Problems in Western Sudan"
J. Teitelbaum

10 - "Nutritional Data from FSR/E in Tanzania"
J. Due

11 - "Management Issues in Linking Research and Extension in Nigeria"
L. Ega

12 - "Is Farming Systems Research the Cart before the Horse?"
B. Greene

13 - "Management Issues Involved in Linking Crop and Animal Research and Extension in Sierra Leone"
R. A. D. Jones

14 - "The Development and Design of the Virginia FSR/E On-Farm Vegetable Trials"
T. Kalb, J. Caldwell, K. Hinkelmann & E. Compton

15 - "Agricultural Research Planning and Management: A Short Course for Professionals in Agricultural Research and Development"
D. Gibbon & S. Biggs

16 - "MSTAT as an FSR Tool"
R. Freed

17 - "Inproving Shifting Cultivation through Tillage and Cropping Systems in Nigeria"
R. A. Sobulo

| 2:30- 3:00 pm - Tour of FSR Library Collection - Meet at Book Display |

3:00- 3:30 pm - Break: 2nd Floor Concourse

3:30- 5:30 pm - CONCURRENT SESSIONS: ON-FARM RESEARCH METHODOLOGY: Little Theatre
MANAGEMENT OF TEAM BUILDING: Big Eight Room
CROPS & ANIMAL INTEGRATION: Room 212

ON-FARM RESEARCH METHODOLOGY: Little Theatre
Presiding: L. V. Withee

3:30- 4:00 - "A Developmental Approach to On-Farm Resarch: A Pilot Project for Improving Small Ruminant Production in Humid West Africa"
A. Atta-Krah

4:00- 4:30 - "Conducting Village Level Feeding Trials in the Gambia"
S. Russo & N. Patrick

TUESDAY, OCTOBER 15

4:30- 5:00 - "FSR Experiences in Guatemala"
R. Ortiz

5:00- 5:30 - Discussant: David Thruston

MANAGEMENT OF TEAM BUILDING: Big Eight Room
Presiding: John Wheat

3:30- 4:00 - "The FSR/E Teams: Functions, Composition and Implementation"
F. Poey

4:00- 4:30 - "Making the Mixed-Discipline Farming System Model Work: Issue and Management Insights from a U.S. and Egyptian Project"
E. Knop, M. TerKuile, W. Schmehl & M. Beebe

4:30- 5:00 - "Communication Aspects of Farming-Extension-Research Linkages in Farming Systems Research/Extension"
D. Esslinger & C. McCorkle

5:00- 5:30 - Discussant: Natalie Hahn

CROPS & ANIMAL INTEGRATION: Room 212
Presiding: Berl Koch

3:30- 4:00 - "Small Ruminant Production in Mixed Farming Systems: Case Studies in Research Design"
C. O. Okali & H. C. Knipsheer

4:00- 4:30 - "Integration of Crops and Animals in On-Farm Research in Northern Nigeria"
J. Olukosi & A. Ogungbile

4:30- 5:00 - "Improved Integration of Legume Crops into the Agro-Pastoral System of the Nuba Mountains, Sudan"
W. Bunderson, T. Woldetatios & T. Gillard-Byers

5:00- 5:30 - Discussant: Jim Oxley

6:30- 8:00 pm - Banquet: Main Ballroom
Presiding: Vernon Larson, Kansas State University
Address: "Regenerative Agriculture: Imperatives for Tomorrow's Technologies"
C. Francis

WEDNESDAY, OCTOBER 16

8:00-12:00 pm -	Book Display: Cottonwood Room, K-State Union
8:00-12:00 pm -	AGRICOLA Online Demonstration: Cottonwood Rm. K-State Union, J. T. MacLean, NAL

8:00-10:00 am - CONCURRENT SESSIONS: DESIGNING ON-FARM TRIALS: Little Theatre
TRAINING: Big Eight Room

DESIGNING ON-FARM TRIALS: Little Theatre
Presiding: Gerald Wilde

8:00- 8:30 - "Increasing Productivity of Rice Small Holder Farming Systems in Sri Lanka: A Case Study"
U. R. Sangakkara

8:30- 9:00 - "Generating Appropriate Maize Technology in Mangwende: A High Potential Communal Area in Zimbabwe"
E. Shumba

9:00- 9:30 - "On Farm Research: Some Alternative Approaches"
D. Gibbon

9:30-10:00 - "The Inclusion of Time Factors in the Design of On-Station and On-Farm Trials: A Case Study from Kilosa District, Tanzania"
L. Lev

TRAINING: Big Eight Room
Presiding: L. H. Harbers

8:00- 8:30 - "Training International and Domestic University Students in Rapid Rural Appraisal: FSR/D "Sondeo" Laboratory at Virginia Tech"
J. Caldwell, A. Neilan, & E. Pehu

8:30- 9:00 - "The Farmer Involvement Program: A Case Study Linking Agricultural Training and Extension in Liberia"
D. Meyers

9:00- 9:30 - "Agricultural Education and Farming Systems Orientation in a Third World Context: The Systeme Des Stages at the Institut Agronomique et Veterinaire Hassan II, Rabat, Morocco"
R. Riddle, P. Pascon & A. Arrif

9:30-10:00 - Discussant: S. Cheema

10:00-10:30 am - Break: 2nd Floor Concourse

10:30-12:00 pm - CONCURRENT SESSIONS: ON-FARM TRIALS: Little Theatre
INTRA-HOUSEHOLD ISSUES - Big Eight Room

ON-FARM TRIALS: Little Theatre
Presiding: Gerald Wilde

10:30-11:00 - "Resource-Efficient Experimental Designs for On-Farm Research"
T. Barker, C. Francis & G. Krause

WEDNESDAY, OCTOBER 16

11:00-11:30 - "FSR/E in Harsh Environment: Development of a Farmer Cooperator Approach in Botswana"
D. C. Baker & D. W. Norman with Berl Koch

11:30-12:00 - "Farmer Participation in On-Farm Trials"
C. Lightfoot

INTRA-HOUSEHOLD ISSUES: Big Eight Room
Presiding: Meredith Smith

10:30-11:00 - "Intra-Household Resource Allocation Constraints in the Implementation of the Banana - Coffee Development Programme in the Kagera Region, Tanzania"
A. Tibaijuka

11:00-11:30 - "Farm Labor by Age and Sex in Northwestern Syria"
A. Rassam

11:30-12:00 - "The Intra-Household Project Worldwide"
S. Poats & H. Feldstein

12:00- 1:30 pm - Lunch: Main Ballroom
Special Luncheon on Food Consumption Issues in FSR/E
Book Display Drawing (winners announced)
Symposium Evaluation

1:30- 3:30 pm - ON-FARM TRIALS & THEIR RESULTS: Little Theatre
Presiding: Jan L. Flora

1:30- 2:00 - "On-Farm Trials Conducted at Farhatabad Village, Central India for Testing of Improved Vertisol-Management Technology"
R. Hardiman

2:00- 2:30 - "Impact of Cropping Systems Program at Sukchaina, Nepal"
B. Singh & K Sayre

2:30- 3:00 - "Farmer Participation in Indonesian Livestock Farming Systems by Regular Research Field Hearings"
H. C. Knipscheer & K. Suradisastra

3:00- 3:30 - Discussant: Randall Barker

3:30 - Closing Comments

The Farming Systems Support Project will conduct its annual meeting following the Symposium on the evening of October 16, all day October 17 and finishing at noon on October 18.

6:00- 8:00 pm - Post-Symposium Dinner - Please sign up by noon Monday
"Food Consumption Issues in FSR/E"
P. O'Brien Place
M. Mack
T. Frankenberger

INTRODUCTION

Cornelia Butler Flora and Martha Tomecek

Management and methodology were two major issues that emerged in the 1984 FSR/E Symposium and therefore served as the theme for the 1985 Symposium. Farming systems research and extension has grown increasingly as an approach to international development, particularly development directed toward limited resource farm households in high risk environments. The philosophy of an FSR/E approach is widely accepted, and teams in more than 50 countries around the world are attempting to implement a variety of versions. Two key areas, management and methodology, were felt to need further comparison, discussion, and perhaps codification. Much of what had been implemented in the early 1980s was either theory directed, needing considerable refinement in moving from the abstract to the concrete, or necessity led it to emerge from the particular situation, but without sufficient consideration of its rationale or generalizability. The papers chosen for this volume attempt to bridge the gap from ideal to real, from specific to generalizable.

The volume begins with the consideration of management. The first three papers systematically analyze the experience from six projects located in the West Indies (CARDI), Panama, Egypt, and the San Luis Valley of Colorado in the United States. All the authors focus on process as well as structure, and stress the importance of the relation of the project and project personnel to the environment. Sands, et al., in particular, address the delicate balance between political viability and total invisibility in maintaining a long term project that becomes a regional program. In the rich detail and systematic analysis provided in these papers, the problems of ambiguity as a stumbling block for management are made clear. Ambiguity, while often protecting the individual researcher, has strong negative implications for project institutionalization. Ambiguity can involve goals, authority, and responsibilities.

The next five papers present the development of FSR/E programs in national systems. All the papers stess the need for institutional change to incorporate an FSR/E approach and thus, to more effectively serve the needs of limited resource farm households. Bingen and Faye discuss the development of such a program in Senegal, Ly, et al., in Niger, Fumagalli, et al., in Guatemala, and Spring in Malawi. Institutional innovations include not only redefining the aims of agricultural research, but in redefining the farmer as well. Musser, et al., look at the potential of including an FSR/E approach in dealing with small farmers in the United States. They, as do the other authors, contrast the established practice (that of the Land Grant System in the United States) with the new set of goals and procedures implied by FSR/E.

One of the key elements in an FSR/E approach, is the interdisciplinary team that works together throughout the development process. The papers by Poey and Esslinger and McCorkle demonstrate the importance of team building, based on their own project experience. Communication within the team, including team definition, as well as communication to the outside, linking the team to resources, is shown to be important for project success and program institutionalization.

Training is a key part of management, although not always viewed as a management function. Greene's short piece makes the pivotal nature of training clear for project success in Bangladesh. Gibbon and Biggs present the rationale and implementation of an alternative training program in FSR/E in the United Kingdom, primarily aimed at developing country practitioners, while Caldwell, et al., give details on training on a specific FSR/E methodology, the sondeo, in Virginia.

The second section of this volume addresses key issues in FSR/E methodology. The first part of the methodology section deals with diagnosis, which is both the first stage in any FSR/E project and a continuing process for project adjustment. The papers in this section, which draw on diagnoses carried out in Indonesia, France, Ecuador, the Philippines, Zambia, and Brazil, show the importance of having the goals of diagnosis in mind when it is undertaken, rather than simply gathering data for its own sake. The difference between FSR/E diagnosis and ordinary socioeconomic or agronomic descriptive studies is that FSR/E is intervention oriented. Bartlett and Arifin demonstrate how considerations of resource distribution guided the diagnosis they carried out in Indonesia. Capillon, in diagnosing crop/animal farming systems in France, found the necessity of keeping in mind the macroeconomic context of farm initiation, indicated by age and life cycle stage of the farm household, when considering recommendations based on the diagnosis. Cornick and Alberti stress, through examples of projects in Ecuador and the Philippines, the complexity of farming systems and how an incomplete understanding of the system affects subsequent research. Njobvu's diagnosis in Zambia, clearly demonstrates the importance of infrastructure, and the market access it implies, in establishing recommendation domains based upon diagnosis in Zambia. Zaffaroni, Barros, and Araujo, in carrying out their diagnosis, attempt to link the actual farming systems with changes necessary in the research and extension program in the northeast of Brazil.

A number of the papers throughout this volume demonstrate the need for considering intrahousehold issues in FSR/E for project success and program institutionalization to occur. Two papers, using diagnostic techniques that strongly favor systematic surveys and over-time approaches, underline the degree to which gender issues, including provision of labor and access to resources, influence recommendations to be made if those recommendations are to be adopted. Rassam looks at farm labor by sex in Syria, while Tibaijuka looks at resource allocation and alternatives in Tanzania.

Diagnosis identifies what intervention may be necessary and feasible to improve the situation of the farm household. On-farm research is then carried on in light of that diagnosis to determine the technological and economic feasibility of the proposed intervention. On-farm trials are often identified as the key defining feature of FSR/E. The papers presented in this section show it is also one of the most variable features.

Barker and Lightfoot conducted a survey of FSR/E projects in order to determine the state of the art of on-farm trials. Using data gathered in the summer of 1985, they found a number of major weaknesses in the current practice of on-farm trials, including a narrow crop focus, lack of social science input, a tendency to ignore system interactions, top-down experimental procedures, over-extension and lack of identification of needed technological research, and unrepresentativeness of participating farmers. Their systematic comparative analysis suggests that while the ideal for on-farm trials is logical, it is extremely difficult to implement. Given the problems in actual practice, Gibbon suggests some alternative approaches to on-farm research. He stresses both upward and downward linkages, to farmers and experiment station researchers as necessary in improving on-farm research practices.

The next part of the methodology section presents specific case studies utilizing on-farm trials. Nagy, Ames, and Ohm detail the use of on-farm trials to evaluate technology in Burkina Faso. They demonstrate why evaluation must include intrahousehold considerations which can then relate directly to policy changes. Singh and Sayre examine the impact of a cropping systems program in Nepal, using on-farm trials in the traditional, and effective way to determine recommendations to farm households. Hardiman reports on ICRISAT's on-farm trials in India to improve vertisol management

technology. Farmer opinion and acceptance proved key for the recommendations and further research stemming from the trials. Sangakkara presents the results of on-farm trials in Sri Lanka.

Issues of experimental design are addressed by Barker, Francis, and Krause. They present alternative field plot designs that can better meet the needs of researchers, extension personnel, and farm families. Diop, Livingston, and Campbell present a model for examining farmer/herder interaction. The difficulties of designing crop/livestock on-farm trials, as well as the difficulty of analyzing interacting livestock and cropping systems, are partially overcome by utilizing the model presented. Okali and Knipscheer present case studies of research designs aimed at small ruminant production in mixed farming systems. They call for simplified designs and greater use of producer trials, using data from Java and Nigeria to show their utility.

Four case studies of on-farm trials in animal-based farming systems are presented in the next methodology section. Through these systematic case studies, the importance and difficulty of carrying out such on-farm trials is shown. Olukosi and Ogungbile present a case drawn from northern Nigeria; Koch, Masikara, Heinrich, and Matlho give a Botswana example. Russo, Patrick, and Deffendol shift the level of analysis from the farm to the village in presenting their case study. Bunderson, Woldetatios, and Gillard-Byers, although focusing on legumes, stress the crop/animal interaction in their on-farm trials in the Sudan.

The case studies in this volume implicity support the utility of farmer participation in FSR/E. Yet, the comparative study carried out by Sigman and McArthur of FSR/E projects, suggests that such participation is rare, and often superficial when it does occur. Lightfoot presents a project in the Philippines in which the research is designed to maximize farm household input at various stages of the FSR/E process. Baker and Norman give concrete examples of the limits of current farmer participation in their presentation on the development of a farmer cooperator approach in Botswana.

Several of the papers stress the need to look at additional factors in determining the goals for on-farm trials and intervention recommendations that would both aid in the short term adoption of the recommendation as well as aid the long term stability of the agroecological system. Francis, et al., take a look at regenerative agriculture, suggesting that such an approach is necessary for long term success, but may be antithetical to short term "fixes" in agriculture. Matzke, Pease, and Vincent also stress the environment, but in a slightly different way, suggesting the need for a methodology for environmental impact as part of FSR/E. Lev, drawing on data from Tanzania, emphasizes the need to include time factors, particularly cyclical ones related to the cropping calendar, in designing interventions and on-farm trials. Finally, Mittal looks at the structural properties of plants and relates them to the total household system needs as ex ante analysis prior to formal recommendations and on-farm trials.

The papers in this volume were submitted to peer review. Two and sometimes three FSR/E practitioners from all over the world lent their time and expertise in reviewing each paper. Often extensive revisions were suggested. The authors whose papers appear complied with these suggestions, as well as making additional changes, raised the quality of the papers far beyond those of a normal proceedings volume. Thus, we are not entitling this volume as a proceedings, but simply Management and Methodology, to underline the commitment made by the reviewers and the authors to provide a standard against which FSR/E publications could be judged.

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LESSONS LEARNED FROM FSR/E PROJECTS

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MANAGEMENT SYSTEM DESIGN AND IMPLEMENTATION IN THE CARDI FARMING SYSTEMS RESEARCH AND DEVELOPMENT PROJECT

Robert D. Hart
Marcus D. Ingle

Farming Systems Research and Development (FSR/D) requires continuous synthesis of physical, biological and socioeconomic information, and a systematic application of this information to the design and evaluation of agricultural technology. It requires a multi-disciplinary team effort. An innovative feature of FSR/D is that it includes the generation of alternative technology and the delivery of alternative technology to appropriate development and research institutions.

FSR/D projects are difficult to manage. This is because multi-disciplinary research is complex. FSR/D bridges the gap between research and development making FSR/D management even more complex. A project management system that can deliver the necessary inputs to the research process, manage the multi-disciplinary team research, synthesize and deliver outputs to development institutions, and coordinate the input, research, and output management processes is a prerequisite for FSR/D. Design and installation of a project management system is a key question that must be addressed by anyone recommending a FSR/D approach. This question provides the focus for this paper.

The paper is divided into the following four sections:

1. FSR/D Management Needs: a systematic assessment of the management requirements for FSR/D projects.
2. A FSR/D Project Management System: a description of a general FSR/D project management system that meets the needs identified in the first section.
3. The CARDI FSR/D Project Management System: a description of the project management system of a real FSR/D project that illustrates the characteristics of the general project management system described in the second section.
4. Installation of FSR/D Project Management Systems: a description of an approach to the development of appropriate management systems and the identification of principles that can guide their installation.

FSR/D Management Needs

A FSR/D project is a system with inputs and outputs. The first step in analyzing the management needs of a FSR/D project is determining what management systems are needed to insure critical inputs are available, the research process operates, the outputs are delivered in a usable format, and the project as a whole functions as a system. The four categories of management needs are: (1) Input Management Needs; (2) Research Management Needs; (3) Output Management Needs; and (4) Coordination Management Needs.

Input Management Needs

All farming systems research and development projects require the following inputs: (1) human resources, (2) physical resources, (3) financial resources, (4) appropriate FSR/D methodology, and (5) basic agricultural technology.

Human, physical, and financial resources are interrelated since financial resources can be converted, to a limited extent, into human or physical resources by hiring people or buying commodities. However, in most projects, this decision is made at the project design stage with the budget already divided by line item (sometimes arbitrarily) before a project manager is given control over the project resources. For this reason, in the following analysis, the three types of resource inputs are discussed separately.

Human Resources

In most projects, the quantity and general qualifications of the individuals hired or assigned to the project are defined at the project design stage. Most project managers have little control over the number and type of people hired. However, they do have some control over three human resource management activities that can be important to the success of a project. These are: (1) internal organization of staff, (2) upgrading of the skills of project staff, and (3) selection of outside technical consultants.

Staff organization is relatively inflexible since once an organizational hierarchy has been installed any major changes can be disruptive. Minor changes in the amount of power given to different positions can have important management implications. Training of staff and selection of technical consultants do not add to the quantity of human resources available to a project, but can significantly affect the quality.

Physical Resources

The quantity and quality of most of a project's physical resources (vehicles, agricultural chemicals, etc.) are also defined at the project design stage and the acquisition of physical resources is not usually the responsibility of the project management staff. A major problem is that donors often require that physical commodities be purchased from a specific country and often require complex procurement procedures that can cause a delay in the acquisition of urgently needed commodities. Because procurement procedures are complex, projects are often not given the responsibility for procurement and individuals who do not feel the effect of a lack of commodities are given the responsibility for management of this input.

While projects may not be given the responsibility for the initial procurement of physical inputs, they usually are required to install a

management process to insure the re-supply of expendable items (as opposed to fixed assets). Ideally, a project needs a storage area, an inventory process to quantify how quickly items are used, and aN ordering system for replenishing supplies. It is sometimes assumed that these input processes will be managed at the program or institution level rather than at the project level; however, many of the institutions implementing FSR/D projects do not allocate central funds to the management of expendable items. As a result, lack of inexpensive items, such office supplies, can sometimes be more of a problem than lack of expensive fixed assets.

Financial Resources

Financial resources for operating expenses, travel, per diem, etc., are usually managed through three inter-related processes: (1) budgeting, (2) accounting, and (3) reimbursement/disbursement.

Most project budgets are developed during the design stage, but project managers usually have flexibility in moving money between years and, more important, in allocating funds among different research teams. Accounting is probably the central financial resource management process since an understanding of past patterns of expenditures is needed to develop realistic future budgets and is essential for managing a reimbursement/disbursement process. A reimbursement/disbursement process is needed to keep cash flowing into the project and to the researchers. If the funds for a project come from outside an institution, a system for reporting expenditures and receiving reimbursement is essential. Money available in theory (in the budget) but not in practice (in the bank) is worthless to a research scientist. Once the money flows from the donor to the project, the funds should be disbursed funds to the research teams.

Methodology

Methodology is quite different from the resources discussed above, but it is an essential input to any FSR/D project. Unfortunately, the management of this input is not often systematically considered. FSR/D is a set of techniques that do not belong to any one discipline and the selection of these techniques depends on the specific situation. For this reason the selection and updating of the techniques is usually left to individual members of the multi-disciplinary team. For example, agricultural economists review the literature on survey methodology, while plant pathologists keep track of new techniques for estimating disease infestation. Often, the project neglects to systematically update its methodology. When members of the research team leave, part of the methodology is lost to the project and to the institution. A project library and a documented project methodology that is systematically updated are key components of the methodology.

Technology

Agricultural technology is an important project input because FSR/D is a type of applied research. In FSR/D it is assumed that constraints or opportunities will suggest a specific type of technology. In most cases

this technology will be developed by adapting known technology to the situation.

Management of technology inputs can also benefit from a project library since technology includes physical products such as seeds or chemicals and knowledge of how to combine natural resources and physical agricultural technology to produce a desired product. A management process to systematically acquire, evaluate and store technology (both physical products and information) is a requirement for a FSR/D project.

Research Management Needs

FSR/D is a specific type of applied systems analysis. In most cases research is directed at a system. The objective is understanding the system so alternative components can be identified and inserted into the system. The resulting system should function "better" than before. Because the target system for FSR/D is a specific type of farm system, and farmers manage the farm systems, the definition of what is "better" is defined by the farmers.

In most situations, the farmers have a good understanding of how the target farm system operates. Since the adoption of any new technology will ultimately depend on the farmers, most FSR/D projects have incorporated farmers into the FSR/D research team. The team follows a systems analysis process of description and analysis of the target system, followed by the design and evaluation of alternative components. The alternative technology is then made available to farmers with similar farm systems in similar ecological and socioeconomic environments.

The analysis-design-evaluation sequence within the FSR/D methodology is an iterative cycle. A superficial analysis can be sufficient to design preliminary alternatives. In evaluating these alternatives, information is collected that improves the analytical understanding of the system and quantitative models can be developed. These models can be used to design alternatives that can be evaluated and lead to an improved understanding of the system.

When farmers participating in the research are sufficiently impressed with the alternatives to make changes in their own farm systems, the research team can further evaluate the new technology by transferring it to other similar farms. If the technology is appropriate for this larger sample of farms and the farms are representative of a large population of farms of a certain type, the alternative technology can be communicated to all farmers who could use the new technology.

Two characteristics of FSR/D must be considered in the design of a research management system. The first is that FSR/D includes an iterative analysis-design-evaluation process. Since farms include biological processes that usually operate on a yearly cycle (wet season/dry season or summer/winter), the iterative research cycle also operates on a yearly cycle. This suggests the management of this process should operate on a yearly cyclical basis.

The second characteristic affecting the design of research management systems is that it is a model-building process. Rather than operating on a one-year cycle, model-building occurs over the life of the project. This suggests projects need management systems that systematically collect and update what is known about the target farm systems and the effect of inserting alternative components .

Yearly Review, Plan, Budget, and Monitor Cycles

To systematically guide researchers through the analysis-design-evaluation research cycle, FSR/D projects need a yearly review-plan-budget-monitor management cycle. The analysis phase of the research cycle should parallelthe review phase of the management cycle; the design phase of the research cycle should parallel the planning and budgeting phases of the management cycle; and the evaluation phase of the research cycle should parallel the monitoring phase of the management cycle.

An information management system is needed to link research (analysis-design-evaluation) and management (review-plan-budget-monitor). This information management system must bring together: (1) the justification for the research being implemented, (2) the methods being followed, (3) the necessary financial, human, and physical resources, (4) the results of the research, and (5) the conclusions that can be drawn from the research results. If this information is filed so that both researchers and management have access to the same information, the file can be continuously updated as technical data is collected or as assumptions are revised. When research teams work in widely separated areas, research and management must have copies of the same file, and a monthly and/or quarterly report system must be used to keep files identical.

Life-of-Project Model-Building

The yearly research and management cycle should continuously add to the understanding of how the target farm systems function. This understanding may not be a formal model that can be analyzed on a computer, but it should be in a format that can be updated and easily used to design alternative technology. An advantage of packaging the information in mathematical models is that models can be used to do ex ante evaluation of potential technology before doing biological research.

Model building requires a combination of research and management activities. It is a research activity because it is a synthesis of technical knowledge and requires inductive technical expertise; it is a management activity because it is an information management process. In the case of farm system modeling, the information is in the hands of different research teams and in the minds of different individuals with different disciplinary perspectives.

An information management system is also needed to link the technical model building with the research activities. A farm system file could be opened when target farm systems are selected. Each year, when the yearly

review-plan-budget-monitor cycle reaches the review stage, information can be moved into the farm system file and a synthesis of the information collected could be done. This synthesis could be an input to the planning and budgeting management process, as well as a project output.

Output Management Needs

The two primary outputs from all FSR/D projects are alternative technology and improved methodology. While it is true that if the project inputs are available and if the research process occurs as planned, these outputs will be a natural result, it is not true they will automatically be delivered to appropriate institutions in a usable format. Output management systems are needed to insure that this occurs.

Alternative technology is an FSR/D output that becomes an input to development institutions, while the improved methodology is an FSR/D output that becomes an input to research institutions, including the institution implementing the FSR/D project. The output management systems for these two outputs, although strongly linked, must be different because of distinctly different clientele.

Alternative Technology

One way of identifying the management activities needed to insure output is delivered in a format consistent with the project's purpose is to look at the characteristics of the inputs required by development institutions that might use the technology. It is generally assumed that the primary receiving institution for FSR/D project outputs will be agricultural extension. However, extension institutions must work with many other institutions, including marketing boards, government policy and credit institutions, and private sector agricultural chemical and seed supply outlets. Government extension institutions often play a central role in coordinating other institutions so development can occur, but in many situations the lead role is played by other institutions.

Regardless of which institution plays the lead role in agricultural development in a country, several types of information can be provided by FSR/D projects. These include: (1) a precise recommendation of alternative technology, (2) a description of the type of farm system and the ecological and socioeconomic environment where the recommendation has been shown to be valid, and (3) the technical rationale for the specific recommendation for the specific type of farm system.

The precise recommendation is needed so information can be communicated through mass media or other technology transfer processes. The description of the target farm system and the ecological and socioeconomic environment is needed so development institutions can know precisely where and to whom information should be disseminated. Technical rationale is needed because any recommendation will only be appropriate for a specific prototype case. As the ecological and socioeconomic situation changes from place to place and from year to year, the recommendation must be modified.

Improved Methodology

Methodology is a key input to FSR/D projects. It is also a key output. Some FSR/D projects have produced little alternative technology, but have made significant contributions to FSR/D methodology. Some cynical evaluators of FSR/D projects may be tempted to suggest that methodology is highlighted as an output only when alternative technology outputs do not meet the expectations of the funding agencies. In the long run, improved methodology can have a greater development impact than new technology.

The principal clients for FSR/D methodology are the institution implementing the project and other research institutions that are designing or implementing FSR/D projects. To satisfy the first client, a management system that insures institutional memory is needed; to satisfy the second group of clients, a management system that makes the methodology available to other researchers is needed. Institutional memory requirements can best be met through a manual that includes different methodology options for the steps in the FSR/D process. The manual must be updated on a periodic basis.

Coordination Needs

In addition to management of inputs, research, and outputs, FSR/D projects need a central coordination management system. Unfortunately, all project management processes cannot be installed at the same time and most projects do not have the resources or do not allocate adequate resources to efficiently manage the process. Thus the central coordination office must take on responsibilities for management systems that are not in place or are not functioning effectively.

The central office has a guidance role, a monitoring role, an information transfer role, and an evaluation role. The guidance role requires an analysis, a policy decision, and a communication of the policy to those who are making decisions. It requires clear specification of roles and responsibilities and delegation of authority. Guidance provides incentives for appropriate performance and sanctions for poor performance. If the central office develops a budget and indicates a certain type of research will receive priority, it is acting in an information transfer role and in a guidance role.

The monitoring role of a central project office requires systematic tracking of project management subsystems to determine if the overall project is proceeding as planned. The information transfer role requires passing of information from one subgroup to another. The evaluation role requires a value judgement. The question that must be continually asked is, given the changes in the environment and knowledge acquired as a result of implementing the project, is the project strategy still correct or should changes be made?

A central coordination management office needs an effective communication system. Without one, the office will tend to centralize activities. Most FSR/D projects require decentralized management. Field teams often work in widely separated areas and the individuals and teams

need a decentralized management to make decisions quickly. If an effective communications system is in place, management can be more decentralized since the central office will have confidence it knows what is going on in all parts of the project.

A FSR/D Project Management System

Every FSR/D project has its own specific management needs. However, all FSR/D projects need a management system with the following four subsystems:

1. Input Management Subsystem: to insure the project inputs are available when required
2. Research Management Subsystem: to insure the research process occurs efficiently
3. Output Management Subsystem: to insure the research outputs are delivered to the development institutions
4. Input, Research, and Output Coordination Subsystem: to insure inputs, research, and outputs are coordinated.

In the management needs section of this paper, general management processes that could meet the identified needs were suggested. The management system described below integrates those processes to form a general FSR/D project management system.

Figure 1 is a systems diagram of an FSR/D project with the project management activities depicted as circles that interact with flows of inputs and outputs, and with FSR/D activities. The four types of project management subsystems can be subdivided into more specific management activities.

Input Management Subsystem

This subsystem has five types of input management activities that correspond to the five basic inputs of all FSR/D projects: human resources, physical resources, financial resources, methodology, and technology. Managing human, physical, and financial resources in FSR/D projects is not very different than managing them in other research and development projects. However, since FSR/D is a relatively new approach, training and consultant selection can be especially important human resource management activities. Physical resource management requires a procurement system for fixed-asset commodities, and a storage and re-supply system to insure that expendable items are available as needed. Financial management must include accounting, budgeting, and reimbursement/disbursement systems.

The management of methodology and technology inputs to FSR/D projects requires management activities not typical of other research and development projects. FSR/D methodology is still evolving and a project may find itself in a situation where no methodology is available and research must be conducted to develop needed methodology. Basic technology must be available or FSR/D cannot develop alternative adapted technology.

Research Management Subsystem

As can be noted in figure 1, this subsystem has two management cycles and two information files. The review-plan-budget-monitor management cycle interfaces with the FSR/D research process and produces information that is filed in a yearly work plan, budget, and results file. The model building cycle takes information from the review-plan-budget-monitor management cycle and develops life-of-project farm models and technological alternative files.

During the review phase of the review-plan-budget-monitor cycle, the results and conclusions from the last set of research activities are used to update what is known about the target farm systems being analyzed. During the planning and budgeting phases, specific research activities are identified that will lead to an evaluation of alternative farm system components. At the end of this phase, management should have a work plan and a budget and the researcher should have a work plan and the assurance that money, people, and physical commodities will be available as needed. During the monitoring phase, research scientists are implementing the planned research activities and management is monitoring the progress. Assuming the management and scientists have copies of the same work plans, communication between these groups will be to update the work plan.

The model-building cycle must be tightly linked to the review-plan-budget-monitor cycle. Information gathered during the review process is used to identify priority research areas for the next year and to update farm models. During the planning stage, the models can be used to do *ex ante* evaluation of potential lines of research. The validated models become an essential part of the files that describe alternative technology, since they are the basis for updating recommendations.

Output Management Subsystem

The output management subsystem takes information from the two files continually updated by the review-plan-budget-monitor cycle and the modeling cycle, and transfers it to research and development institutions in a usable format. Client institutions, and the institution conducting the FSR/D project must define "usable format." Transfer to research institutions requires management activities that generate technical articles and reports.

FSR/D generates site-specific technology. To make it cost effective, information other than a site-specific recommendation must be transferred. A file with a description of other types and locations of farms that can use the technology and the technical rationale for the recommendation must also be transferred. The technology output to development institutions must be a synthesis of the life-of-project farm model and the alternative technology file (see figure 1). This file should be copied and made available to development institutions as soon as it looks likely alternative technology will be produced.

Coordination Office

The central coordination office must: (1) receive information from the

input, research, and output management systems, (2) analyze this information and (3) regularly disseminate directives to the various management subsystems. The common denominator in these activities is information management. The effectiveness of the central project office in coordinating the input, research, and output management subsystems depends upon the efficiency of the communication and information management system.

The CARDI FSR/D Project Management System

To illustrate how this general FSR/D project management system can be applied to a real project situation, the next section of this paper describes the project management system of a FSR/D project currently implemented by the Caribbean Agricultural Research and Development Institute (CARDI) in the Eastern Caribbean.

The Caribbean Agricultural Research and Development Institute (CARDI) is a regional institution financed by 12 Caribbean territories that are members of the board of directors. In addition, international donors provide funds for specific projects. The Farming Systems Research and Development (FSR/D) Project is funded through CARDI core funds and the United States Agency for International Development (USAID). The project serves eight island nations in the Eastern Caribbean: Antigua, Barbados, Dominica, Grenada, Montserrat, St. Kitts/Nevis, St. Lucia, and St. Vincent. The project has a budget of approximately 10 million U.S. Dollars, to be spent over a period of 5 years beginning in 1983. It was preceded by a cropping systems project that allowed CARDI to hire staff and begin many of the activities that became part of the FSR/D project.

As stated in the CARDI FSR/D Project Charter (CARDI 1984a), the project's goal is improving the economic and social well-being of small and medium-sized commercial farm households. The four major partners in implementing the project are (1) the farmers of the Eastern Caribbean, (2) the Ministries of Agriculture of the participating countries, (3) CARDI, and (4) USAID. The primary purpose of the projeact is to develop a sustainable FSR/D programme within CARDI that is responsive to the agricultural research needs of the Eastern Caribbean. The project's expected outputs are: (1) alternative crop, livestock, and crop/livestock technology, (2) a methodology to generate and transfer technology, and (3) the institutional capability to implement FSR/D projects.

The inclusion of the third output (institutional strengthening) makes this FSR/D project different from most FSR/D projects. A significant percentage of the technical support portion of the project (provided to CARDI thorugh a contract between USAID and the South-East Consortium for International Development) is allocated to the development of institutional management capability and the strengthening of the management of this project. The process followed to design the project. The project's general conceptual framework and research methodology have been described by Hart and George (1984). A key event that occurred between the design and implementation of this project was a project implementation workshop (CARDI 1984b). During this workshop, management specialists from the Development

Program Management Center of the United States Department of Agriculatlure, the International Development Management Center of the University of Maryland, and CARDI developed many of the management concepts and learning processes used to implement the project.

The CARDI FSR/D project is probably more difficult to manage than most FSR/D projects, because it serves eight island countries and it is time consuming and expensive to travel between islands. The Ministries of Agriculture on each island have their own political agendas and the project must continually balance regional research needs with national priorities. The islands have different soils, rainfall, levels of economic development, and cultural backgrounds. On many islands environmental diversity is very high, with annual precipitation ranging from less than 1000 mm to over 3000 mm within a short distance.

The different project management systems that have been designed and installed in the CARDI FSR/D project are discussed below. Many of the management systems have only recently been developed and, undoubtedly, will evolve as project staff gain more experience. Emphasis is placed on innovative features of the management systems. The description of CARDI's FSR/D project management system follows the same outline as the management needs assessment in the first section of this paper, and the description of the general FSR/D management system in the second section.

Input Management Subsystem

Like all FSR/D projects, the CARDI FSR/D project has inputs of human resources, physical resources, financial resources, methodology, and basic technology.

Human Resources

Human resources available to the project include about 35 technical and 10 administrative and secretarial staff. There are 3-person country teams on each island with a secretary/administrative assistant working with each country team. The country teams are assisted by specialists (economist, anthropologist, plant protection specialist, etc.) who reside at the project headquarters in St. Lucia, a subregional coordinator for a group of islands north of Dominica (Leeward Islands), and a subregional coordinator for a group of islands south of Dominica (Windward Islands). There is a project manager and secretarial and administrative staff at the project headquarters. The CARDI office in Trinidad is linked to the project through the provision of technical support, and because a key objective of the project is to strengthen CARDI's institutional capabilities.

The project has a limited amount of funds for training at the graduate level. Most training is done in workshops that have multiple objectives. For example, learning to use specific microcomputer software has been combined with the objective of developing budgets. While this type of multiple objective workshop is a necessity due to budget limitations, there are distinct advantages to "learning through doing".

Technical support from outside of CARDI is obtained through an arrangement with the South-East Consortium for International Development (SECID) in the United States. At the project's annual planning meetings, project staff identify needs and the project manager and a resident SECID representative develop job descriptions for the consultants who are needed. Requests are sent to U.S. institutions participating in the SECID arrangement, and qualifications of potential consultants are discussed with CARDI staff.

Physical Resources

Physical resources are an important item in the CARDI FSR/D project budget. Vehicles have been purchased for most of the islands. Tractors, irrigation equipment, etc. have been purchased to improve field station infrastructure on two islands. An item that has had a major impact on the management of the project has been the purchase of microcomputers and software. Most fixed assets were obtained through an arrangement with SECID. An exception was the vehicles, which were purchased by CARDI immediately after USAID provided the funds. This early procurement occurred because of a USAID policy that right-hand drive vehicles could be procured locally rather than requiring purchase in the U.S. A system of local procurement is used to obtain expendable items.

Financial Resources

The CARDI FSR/D project has accounting, budgeting, and reimbursement/disbursement systems. Accounting is managed by an accountant in the central office and the secretary-administrative assistant who works with each country team. Each island submits monthly statements coded by line item and receipts for expenditures. A project-level expenditure statement is developed and the items that USAID has agreed to fund are submitted for reimbursement. This reimbursement is made directly to the project office, which then disburses funds to the country teams.

A general project budget was developed during the design of the project. After the first year of the project, it was obvious that certain assumptions regarding the cash flow and the possibility of increasing the percentage of the budget that would be paid by CARDI territories were not valid. A more realistic budget was developed using the experience of the first year as a guideline. The new budget was more detailed and estimates could be made on projected research costs for each island. Before each yearly research planning session, the budget is updated and each research team is given an estimate of the financial resources available to them for the year.

Methodology

The methodology for the CARDI FSR/D project was developed by a group of CARDI staff and outside consultants during the design of the project. The FSR/D project was preceded by a cropping systems project that allowed many of the staff to gain experience in on-farm trials and other techniques that are part of most FSR/D projects. This experience allowed CARDI staff members to

develop a relatively detailed methodology during the initial phase of the project.

The CARDI FSR/D methodology follows the traditional description, analysis, design, evaluation, and transfer process of most FSR/D projects, except that the process has been subdivided into 11 activity sets that are sometimes sequential, but often simultaneous. FSR/D applied in the Eastern Caribbean situation requires an understanding of island-level, farm-level, crop and livestock production system-level, and crop and livestock species-level phenomena. The first three activity sets in CARDI's methodology attempt to identify and describe these systems. The activity sets are: (1) target area and farmer selection, (2) rapid reconnaissance, and (3) specific problem surveys.

Activity sets 4-7 in CARDI's methodology involve the analysis of crops and livestock at the field station level, on-farm crop and livestock production system trials, farm-level studies, and island-level or area-focused studies. This information is then used to design alternatives (activity set 8), conduct on-farm testing of the alternatives in researcher-managed trials (activity set 9), and conduct further on-farm validation in farmer or extension agent-managed trials (activity set 10). The final stage (activity set 11) is called "applicability trials", since these experiments are done on farms in areas that are similar to the farms and areas where the technology was developed. The objective is to determine the technology can be transferred to this larger population of farms.

The different techniques used in the 11 activity sets have not all been documented, but a document describing the different options for the different activities will be developed as a project output. The manual will probably have chapter headings corresponding to the activity sets listed above. The project has a library that is presently being organized with the documents described in a microcomputer data management system so staff can request documents by key subjects.

Technology

CARDI FSR/D staff members are aware of the necessity of obtaining basic agricultural technology that can be screened and adapted to the situation in the Eastern Caribbean. The first source of technology for the project has been CARDI headquarters in Trinidad. CARDI maintains active commodity and discipline-oriented research programs. It also has strong ties to the University of the West Indies (UWI). Another institution in the Eastern Caribbean that has provided basic technology is the Institut National de la Recherche Agronomique (INRA) in Guadeloupe. On many of the project islands, CARDI collaborates with the French Technical Mission.

The FSR/D project has obtained improved varieties from many of the international centers and from the United Nations Food and Agriculture Organization (FAO). Even though geographically the Eastern Caribbean is closer to the international centers in Mexico and Colombia, the cultural heritage of the region is such that food preferences emphasize roots and tubers rather than maize and beans. For this reason the project has

emphasized the development of contacts with the international centers in Nigeria and India.

Tourism is important in the project islands and vegetables for hotels (as well as local markets) are important cash crops. The FSR/D project has contracted a scientist from the Asian Vegetable Research and Development Center (AVRDC) to reside in St. Lucia and help the project select improved varieties of vegetables to be tested on the different project islands.

Research Management Subsystem

CARDI's FSR/D methodology was described above in the section on methodology input. The challenge in implementing the 11 activity set process is how to systematically move information through the process and deliver the information to development institutions. During the design of the project, it was decided that the alternative technology outputs should be delivered as part of a flexible information file that could be updated assuming these files would move through the 11 activity set methodology and be transferred to extension institutions. The first management question faced was how to move the files through the process.

Yearly Review, Plan, Budget, and Monitor Cycles

To systematically move through the 11 activity set methodology, the CARDI FSR/D project installed a yearly review, plan, budget, and monitor cycle. During the dry season before the yearly cropping season begins, the country teams meet with representatives of the ministry of agriculture on each island. The previous year's research results and next year's research priorities are reviewed. Tentative work plans are developed and discussed with the subregional (Leeward and Windward island) technical coordinators.

After preliminary work plans are developed at the island level, subregional workshops are held and the yearly budgets are given to the country teams. Finally, country team leaders, technical coordinators and project specialists meet in a project-level regional workshop to finalize the work plan and budget. Coordinators and the project manager then monitor implementation of the work plan.

To manage the information produced by the review-plan-budget-and monitor cycle in operational terms, the project developed the Activity Record Sheets (ARSs) concept. ARSs are files with the following subfiles:

1. data management codes
2. title
3. objectives
4. justification
5. budget
6. results
7. conclusions

The first five subfiles are filled in during the planning and budgeting stage; the results (subfile 6) is filled as data is generated. The

technical coordinators monitor this process and provide technical support in the analysis of data. During the review stage, the conclusion (subfile 7) is filled in, and the ARS is complete.

The ARSs are maintained as microcomputer files on diskettes and on paper. There are two advantages to managing information with microcomputer system. The first is that individual islands can develop their work plans and budgets and bring them to the planning workshop on diskettes. Plans and budgets can be updated and electronically combined so both the project management and the country teams can return to their offices with identical copies of the work plans and budgets. The second advantage is that the completed ARSs can be used in multiple documents, including the annual report, the models, and the alternative technology files described below.

Life-of-Project Model Building

To manage the information developed during the process of identifying alternative technology, the CARDI FSR/D project developed the Technological Improvement Files (TIFs) concept. TIFs have four subfiles: These are:

1. A description of the target farm systems and the target ecological and socioeconomic environment
2. The recommended technological alternatives
3. The technical rationale for the recommendations
4. Ongoing research

Information collected during the first seven activity sets of the FSR/D methodology are used to developed the first subfile. The recommendations are written during the "design" stage (activity set 8) of the methodology. Completed ARSs are placed in subfile three. ARSs that are incomplete because the research is still in progress are placed in subfile four.

Before the TIFs move from activity set 9 (researcher controlled on-farm trials) to activity set 10 (extension and farmer-managed trials), a copy of the TIFs will be physically transferred to extension offices. As new research results are available and as the socioeconomic situation changes, the files will be updated. An important characteristic of island economies in the Eastern Caribbean is that prices and market demands are constantly changing. The possibility of quickly updating recommendations has clear advantages. Farm models that would allow researchers to quickly test to see if recommendations are still valid would be useful.

Output Management Subsystem

As stated above, the CARDI FSR/D project has three types of outputs: alternative technology, improved methodology, and improved institutional capabilities to implement FSR/D projects. These outputs are delivered to three types of clients: (1) CARDI headquarters, (2) development institutions, and (3) research institutions.

Alternative Technology

Technology outputs are delivered to the clients and complete copies of the TIFs will be on file at CARDI headquarters. If research or development activities are conducted in any CARDI territory on farms or in areas similar to those where the files were developed, the information files can serve as a source of technology for these projects.

Extension institutions are the key clients for the alternative technology. CARDI and extension staff will use the files to develop fact sheets and other extension materials. The research institutions most interested in the technology generated by the FSR/D project will be the local Caribbean institutions. CARDI staff actively participate in regional professional meetings. Presentations and proceedings from these meetings will probably be the principal way this technology is transferred.

Methodology

The techniques used to implement the 11 activity sets of the CARDI FSR/D methodology have not been documented; however, before the project is completed a methodology manual will be written. As suggested, the manual will probably have chapter headings corresponding to the activity sets and will be in a format that can easily be updated. This methodology manual will be transferred to CARDI headquarters and made available to all CARDI staff and other research institutions doing FSR/D.

Methodology will be transferred to other researchers primarily through annual reports that are sent to other institutions and through technical articles in journals and proceedings of technical meetings.

Institutional Capability

The primary client for this output is CARDI headquarters. This type of output is not typical of most FSR/D projects and the process to systematically transfer management experience gained in the FSR/D project to CARDI as a whole is still evolving. The first priority was to analyze CARDI to determine its capability to provide the inputs necessary to implement a FSR/D project. Progress has been made towards improving financial and human resource management systems.

An important lesson learned during the initial stage of the FSR/D project was that management capabilities and management systems are a prerequisite for FSR/D. The management capability and management systems that will evolve over the life of the FSR/D project will undoubtedly be important outputs from the CARDI FSR/D project.

Coordination Office

The central office for the CARDI FSR/D project is in St. Lucia. St. Lucia is also the residence of most of the project specialists, the Windward technical coordinator, and the St. Lucia country team. The principle components of the central office are: (1) the project manager's office, (2)

the document and report production/wordprocessing center, (3) the financial resource management office, (4) the microcomputer network central office, and (5) the office of the SECID resident responsible for providing consultants and physical commodities.

The CARDI FSR/D management system is not fully installed. It will evolve and undergo changes over the next few months and years, but the present system is operational. It is not easy to put a management system into place and make it operational because it is impossible for everything to be in place at the same time. The next section of this paper describes some lessons learned and general principles of management system installation.

Installation of FSR/D Management Systems

The strategy used to install the CARDI FSR/D project management system can be defined as a "performance improvement approach". Improvement of the research process is the primary objective. This is very different from designing and installing management systems for their own sake. After a management system has been designed, an appropriate process that will lead to a capability to perform the needed management function is identified.

In the CARDI project, workshops to accomplish management needs and develop capability have been important elements of the installation procedure. To date, the most important workshops have been a pre-implementation management workshop, the planning and budgeting workshops held at the beginning of the project and at the second and third years of the project, and a microcomputer application workshop.

Experience in the design and installation of the CARDI FSR/D project management system, experience with other development-oriented agricultural institutions, and the research management literature suggest there may be some general principles that can be considered in applying the performance improvement approach. Four are discussed below.

Maximum Staff Participation in Design of Management Systems

There are two reasons why this guideline should be followed. First, most research scientists suspect that many management activities are bureaucratic busywork that take time away from doing research. Staff participation insures the rationale for management demands will be understood and more likely acted upon. The second advantage of having project staff participate in the design of management systems is that often they are much more aware of their own strengths and weaknesses than are outside management consultants or upper-level management.

One main reason CARDI was able to quickly install different project management systems was that the institution had just completed a project that required similar management systems. Project staff were aware of their own capabilities as well as their management needs. They also knew CARDI's strengths and weaknesses.

Structured Flexibility

This principle is a consequence of seeking maximum staff participation in the design and improvement of management systems. For staff to be motivated to suggest changes they must believe changes are possible. However, to suggest that "structured flexibility" is required is not the same as suggesting that only "flexibility" is needed. The important thing is to identify what is not flexible, such as specific goals, objectives, etc., and allow maximum flexibility in the design and installation of processes that will achieve the required results.

A good example of the application of this principle is the development of the technological improvement files (TIFs). These files were identified as an output of the project during its design. The general structure of the files was also defined, but the detailed outline and format of the files and the processes needed to develop the files were not identified. In project workshops, small groups have begun to develop the TIF format and suggested processes to insure their development.

Combine High-Demand Tools and High-Need Management Systems

One way to motivate project staff to quickly install a management system is to combine installation of the management practice with the installation of a research or management tool that is in high demand by staff. For example, if a management system is needed to make a soil laboratory function more efficiently, the installation of the management system can be combined with the purchase and training on how to use a new piece of laboratory equipment everyone wants.

In the CARDI FSR/D project, the installation of the review, plan, budget, and monitor process was combined with the installation of microcomputers. The ARSs used to keep track of the information generated by this management process were put on microcomputer diskettes. Instructional materials emphasized "how to put together an ARS", rather than "how to use wordprocessing software", but the possibility of learning to use the computers was undoubtedly a strong motivating force. This motivation was reinforced by the experience of developing the first year's work plans without microcomputers and discovering it took six months to put together a typewritten work plan approved by management. With the microcomputers, a draft of the work plan was finished before leaving the planning workshop.

Management and Methodology Must be Linked

All research projects require management systems that are consistent with the research methodology. It would be illogical to design a management system that requires that budgets be revised every six months if the research program is directed at crops that require more than six months to reach maturity. Conversely a project's methodology must be consistent with what is institutionally possible. For example, there is no use adopting a methodology that requires both social scientists and biological scientists if the institution does not have a policy of hiring both types of scientists.

The CARDI FSR/D project began with a methodology designed by staff members on the basis of their understanding of Eastern Caribbean farm systems. A management system was designed that reflected the methodology. Both the management system and the methodology will probably undergo changes as a compromise occurs between what is technically ideal and managerially possible. One of the reasons the present project management system has been successful is that the management system reflects the methodology.

Acknowledgments

Many individuals, too numerous to mention, contributed to the evolution of the ideas and concepts that were beginning to crystallize when we had the opportunity to participate in the design and implementation of the CARDI FSR/D project. Our participation in the CARDI FSR/D project began in 1983, although both of us had contacts with CARDI previously. While the professional challenge of being directly involved in the implementation of a project that we helped design was an important motivating factor, probably the key factor that convinced us to take up residence (Hart) and accept "long" short-term consultancies (Ingle) was the chance to work with the CARDI staff we met during our project design consultancies. These same CARDI staff members have been and will continue to be the force behind the development of the project management system described in this paper. We would like to specifically acknowledge the contributions of Dr. Samsundar Parasram, the Executive Director of CARDI, and Mr. Calixte George, the FSR/D Project Manager. Many senior management staff in Trinidad, and all of the staff of the FSR/D project participated in the development of the project management system described in this paper.

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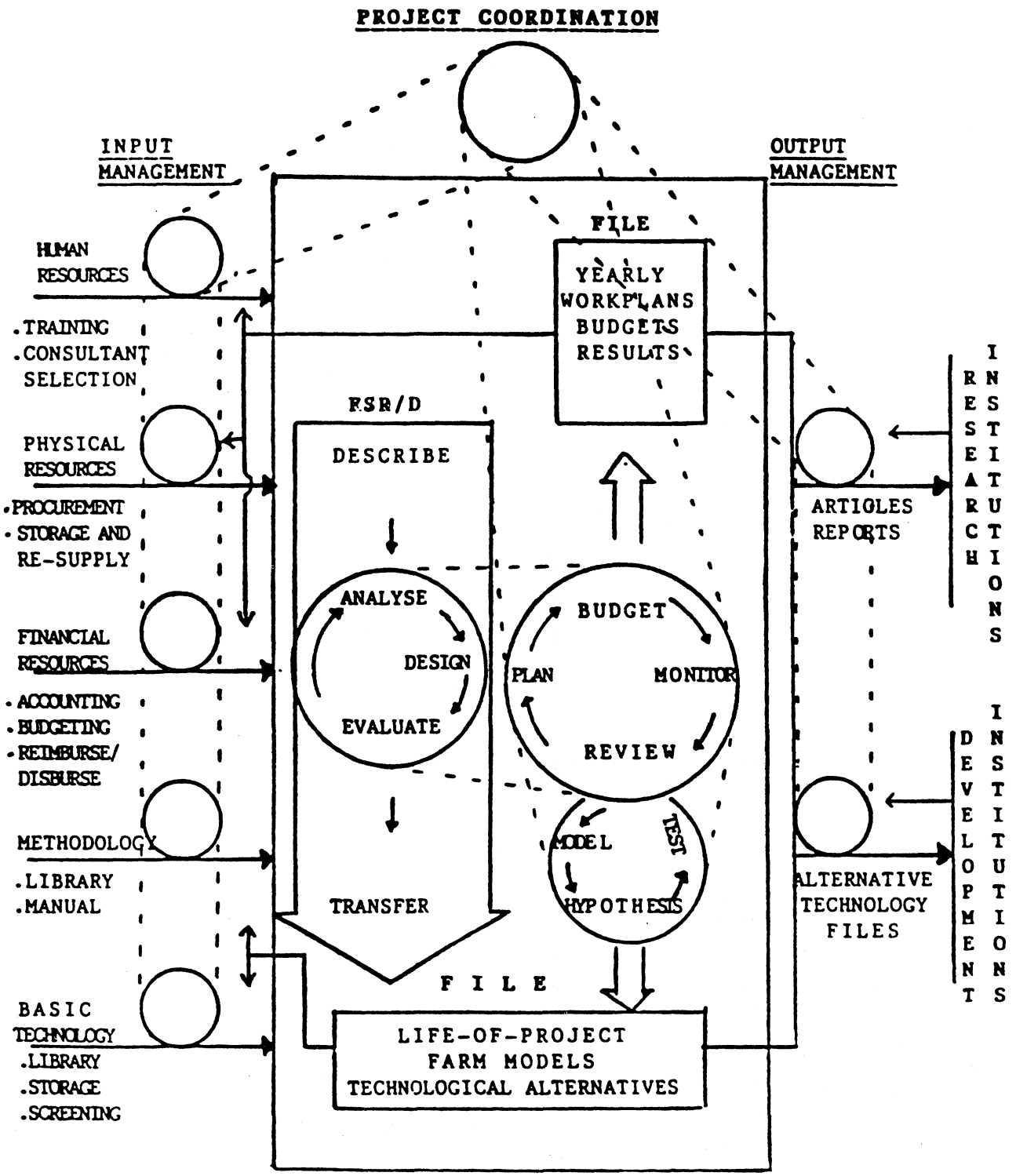

Figure 1. A project management system for a farming systems research and development project.

MANAGEMENT EXPERIENCES FROM THREE FSR/E PROJECTS IN WESTERN PANAMA

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INTRODUCTION

Since 1978, three different Farming Systems Research and Extension (FSR/E) projects have been underway in western Panama under the guidance of the Panamanian Agricultural Research Institute (IDIAP) and in collaboration with other external institutions. These three have concentrated in different recommendation domains and different farming systems. All three have been managed slightly differently and together offer some lessons for researchers and administrators in the management of of FSR/E projects. Our intent in this paper is to familiarize others with some of the implementation problems and possible solutions so as to avoid the pitfalls we have experienced. Undoubtedly there will be others that we have not encountered.

AGRICULTURAL RESEARCH IN PANAMA

IDIAP was created in 1975 as an autonmous institution with a mandate to develop agricultural technology appropriate to Panamanian conditions. In 1978, IDIAP decided to concentrate its efforts in selected areas of the country in order to more efficiently utilize its scarce resources. The process of ranking the various areas of the country involved consideration of present agricultural activities, the potential for improvements and institutional presence. As a result of this process, eight priority areas for both crop and livestock production were selected (Avila, 1983).

In Chiriqui Province three of the areas were selected as locations for FSR/E oriented research in conjunction with international centers and US universities.

1. In Bugaba, IDIAP technicians supported by a resident animal scientist from CATIE focused on dual purpose cattle production systems (Sands and Hertentains, 1985).

2. Baru is a rice, maize, and sorghum area in which IDIAP technicians supported by a resident research team from the Tropical Agricultural Research and Training Center (CATIE) have completed a 5 year FSR/E project (Bejarano et al., 1985).

3. Caisan, a maize and bean area, was selected for use in testing of the FSR/E methodology developed by CIMMYT (Arauz and Martinez, 1983).

All three projects had as a basic philosophy, a "farming systems" approach. Basically this entailed a commitment to initiating the research from an understanding of the existing farming system and including the farmer as an integral member of the research team. Each project had 5 sequential stages that could be labelled:

- Area Selection,
- Characterization,
- Design,
- Validation,
- Extension.

Various types of research designs have been conducted in the other priority areas of Panama. The selection of research methodologies depended on sites, crops, and clientele. Research continues in all these priority areas as IDIAP continues to expand its domain to all important agroecological areas of Panama. It is hoped that much of what is developed in an area will have a wider applicability based on an accurate definition of the agroecological zones of the country.

While IDIAP has adopted a "farming systems" approach to research in several areas of the country, it has maintained a more traditional institutional structure along disciplines and products at the national level. At the regional levels there has been an attempt to cut across these in "area focussed" research programs.

One important consideration in the following discussion is the status of the extension service in Panama. Technically, extension is the mandate of the Ministry of Agricultural Development (MIDA). However, during the period discussed (1978-1985) it has been essentially dormant thereby requiring IDIAP to unofficially expand its focus to include both technology generation and transfer.

HISTORY OF INDIVIDUAL PROJECTS

Bugaba

In 1979, IDIAP and CATIE started work in Bugaba, an area (Figure 1) approximately 35 km west of David, the provincial capital and site of IDIAP regional headquarters. Access both to and within the area is good with the Interamerican highway bisecting the District and acceptable feeder roads reaching most the area. An area office was established by IDIAP in 1980.

After an initial area selection, a single point survey was carried out in December and January of 1979/80 in order to more accurately define the recommendation domain(s). Based on these initial surveys a decision was made to concentrate on farms that had as their major enterprise dual purpose cattle.

Early attempts to define the recommendation domain based on the farmer's management focus (proportion of meat to milk) were frustrated by the flexibility of the system. This flexibility was, in fact, one of the most attractive features of the dual purpose cattle production system in comparison with a pure beef or dairy system. Farmers would often shift in and out of milk production within a given lactation as a response to changes in labor availability or cash flow needs. The recommendation domain was therefore defined for dual purpose cattle farmers on the basis of location and farm size (hectares, numbers of cattle).

After 1 year of monthly data collection to further describe the dynamic aspects of the cattle system, a first approximation of the alternative was implemented on 5 farms. Questions arising from holes in the information generated by the baseline monitoring survey or in the design of the alternative were the subject of more specific experimentation, either on farm or at the Gualaca Experiment Station. Formal experimentation was therefore a component of both the characterization and design stages. Monthly data collection has continued on the test farms as well as farms without the alternative. On the basis of further observation the alternative has been modified several times.

In December 1984, the alternative had been tested for 2 years on 2 farms and 1 year on 3 farms. External funding was then only available for 6 months of data analysis and report writing. Using national funds, IDIAP has continued monitoring the 5 test farms until the present date. The extension service personnel of MIDA and the two agricultural banks (BNP, BDA) have collaborated with IDIAP research staff in the presentation of the tested technologies to area farmers.

This project was a collaborative effort and therefore drew its resources from various sources. IDIAP provided 2 technicians (1 diplomate, 1 university graduate) that both worked half-time on the project. An office/dormitory in the area, a secretary, 1 old pickup, 1 motorcycle and limited vehicle support (diesel, repairs, etc.) were also provided by the national institution. CATIE provided 2 diplomates, 2 jeeps, and $15,000 annually in supplies (diesel, day laborers, field supplies, office supplies). In addition, CATIE provided a resident animal scientist who acted as co-team leader.

Baru

Baru is located approximately 1 hour west of David (Figure 1) along the Costa Rican border. The predominant agricultural activities are rice, maize, sorghum, bananas, plantains, and cattle production. Many of the small farmers in the area are organized into large collectives with the land farmed as a large single unit.CATIE and IDIAP selected the area in 1979 for collaborative research.

In 1980, after an initial year of characterization and exploratory experiments, it was decided to define the recommendation domain as farmers whose principal agricultural activity was the commercial production of rice followed by fallow, rice, maize, or sorghum. Technical packages were developed for rice, maize and sorghum. Two separate zones were defined based on soil types.

A system of core and satellite experiments was designed such that individual factors were tested at various levels and then in combination with other factors (Bejarano et al.,1985). Factorial and missing factor were the principal designs used. Factors included variety, fertilization (N,P,K,lime), weed control, pest control, and land preparation. All experiments were carried out in producers' fields but under management of the technical staff.

In the spring of 1982, the first approximation of the alternatives were tested in farmers''s fields under the farmers management. As the core and satellite experiments were continued, further modifications were made in 1983 and 1984. In 1985, the new MIDA extension service in conjunction with IDIAP and the banks started disseminating the recommendations on a wider scale to area producers.

To support this research, IDIAP provided an area office, 2 technicians, and a secretary. CATIE provided 1 technician, 1 jeep, 2 motorcycles, and $20,000 worth of operating expenses annually. CATIE also had an entomologist and a soil scientist/agronomist in David working 1/2 time on this project.

Caisan

In 1978, IDIAP started its first FSR/E oriented project in the area of Caisan (Figure 1). Caisan is approximately 2 1/2 hours from David in an area of poor accessability. Internal roads and communication are minimal. The majority of producers in the area are small farmers producing maize and beans.

The work started with an analysis of previous work in the area by IDIAP, MIDA, and CATIE. This was followed by a "sondeo" and later a more formal single point survey that permitted a description of the agroeconomic conditions, the agronomic practices and an initial estimate of the first limiting factors to maize production. On the basis of this, exploratory trials were initiated to define levels of various factors.

In 1981, the first validation trials were started for maize in farmers fields. In 1982, in conjunction with the economics program at CIMMYT, a partial economic evaluation of the project encountered a very high adoption rate of the recommended technologies for maize (Martinez and Arauz, 1983). A similar though less formal program has occurred with field beans. Further research is continuing in the area refining the alternatives particularly in the area of soil fertility management. This later work has been partially supported by Rutgers University.

IDIAP provided most of the resources for this project. Some early data was collected by MIDA, CATIE, and the banks. IDIAP has a local office/dormitory, 1 4WD vehicle, 1 motorcycle, 2 technicians and a secretary in the area. CIMMYT has provided specific backup in economics and agronomy from their Mexico headquarters. Rutgers has provided a resident agronomist with a vehicle and small research fund working half time in Caisan since 1983.

OUR EXPERIENCE WITH MANAGEMENT PROBLEMS

Planning and Relevance to the External Environment

We have encountered perhaps our largest problem in this area of adequate long term planning. The capacity to do long term planning was severly hampered by the political instability of the agricultural sector and country as a whole. Since 1982, on average, a new Minister of Agriculture was named every 6 months. As a matter of course this meant frequent changes in policies and personnel. Often the policy changes were quite drastic; for example moving from a priority on import substitution to a reliance on free imports and then back again, or changing the organizational structure of MIDA or IDIAP. While these changes were more drastic at the national level, the regional repercussions were detrimental to development of long term program priorities and funding stability.

Any project (FSR/E or otherwise) rapidly loses much of its credibility and impact when its results are not in concordance with macro level development policies. This often happens as policies change over time in response to political pressures. In Baru, for example, the project originally identified rice cultivation as an area for improving the economic well-being of the farmers as well as important to national goals of rice production. However, 5 years later, increased rice production was no longer a government interest. Similarly, small producers in Bugaba could produce more milk in more intensive systems, but as yet there is not the market incentive in the present national policies.

To avoid these types of problems, it essential that the planning department of IDIAP have a very clear picture of the national development policies and are able to convey these to researchers within the institution. This is, however, impossible when the government itself cannot maintain a coherent long range policy.

Administration

As the FSR/E projects were administered within the existing structure of IDIAP, often a conflict existed between the requirements of national and regional administrators and the management planning within the projects. This was particularly true in relation to administration of finances and committee meetings.

One of the basic problems in administrative planning of FSR/E projects is the nature of the "less developed" small farmer. He has not usually had the resources or habit to commit himself to a given appointment in the future. In poorly accessible areas his schedule is planned day by day. He is also not used to expecting much from government institutions except for trouble. All this implies the need to anticipate the communication and follow through problems and to plan for them.

Frequently, technicians were not fully aware of the time required for various activities. The process of analyzing experimental data, designing new trials, selecting sites, contacting farmers, and obtaining supplies often took much longer than expected. Further delays in the release of funds for

administrative reasons while part of the normal procedures were none the less frustrating to field researchers watching the planting season slip by. The anticipation of the needs of this process requires a fairly complete planning process if meaningful research is to take place.

The most effective strategy encountered in Panama has been to have regularly scheduled staff meetings where all progress and problems are regularly reviewed. In Bugaba, Friday afternoons were used for all the staff to meet in the area office to review the weeks work and prepare a detailed, written program for the next week that included all staff and vehicles. Any unavoidable changes were to be noted on a posted weekly schedule. Thus any team member arriving from outside would always know where all staff were at a given moment. Initially the CATIE resident animal scientist attended all these meetings. As the capabilities of the team improved the Area Leader became responsible for managing these. The CATIE resident, Area Leader and several other staff met somewhat less frequently to discuss longer term planning needs and strategies for incorporating the project requirements into IDIAP's national planning.

One reason for inadequate planning has historically been the delays in data analysis. Efficient experimental design requires the results of previous experimental cycles. Sending the data to the capital city or even out of the country for coding and analysis typically entails delays of up to 2 months under the best of circumstances. The use of powerful handheld calculators and more recently micro computers have done much to reduce data analysis delays.

Managing the mass of data generated by monitoring cattle farms initially overwhelmed not only the national staff but the computer center at CATIE. During the last year of the project, in conjunction with an IDRC funded project, we have been successful in designing a data management system based on an IBM PC and off the shelf spreadsheet programs. Data is entered by the enumerators immediately after collection. The printout is then available for the next visit for confirmation. Additional tasks such as statistical analysis, report writing, and financial book-keeping are also done on the computer to varying degrees. Microcomputers and off the shelf software have also been used effectively in Caisan during the last year. This experience has stimulated IDIAP to invest in microcomputers for other projects and areas.

Lack of Experienced Researchers

Not surprisingly, it was extremely difficult if not impossible to find research staff with FSR/E experience. This problem was often complicated by the transfer of staff after considerable investment in time and effort to train them. In Baru, there were 4 area leaders in the life of the 5 year project.

Given the structure of the institution and nature of on-farm research, many researchers especially those with advanced training prefer to be based in national headquarters or the experiment stations. Experiment station research typically has clearer goals, is safer, more understandable, and "cleaner". It is often politically more glamorous.

FSR/E projects, in fact, need higher quality staff who can manage complicated goals and work in teams often without much support. They must be capable of making decisions with respect to people, budgets, and experimental design. In reality the only feasible strategy to overcome these problems is to train the majority of the staff within the project. All 3 projects invested considerable time in training. In addition to on the job training, many staff members attended symposia, workshops and short courses in and out of the country.

Lines of Responsibility

The above problem was often complicated by the uncertain lines of responsibility and communication that existed because of a national organization along discipline lines and a regional organization focused on areas. This is further complicated with the inclusion of social scientists from the planning department in research teams that are typically placed within the research departments.

With nonexistent or poor communication infrastructure in the areas it is essential that meetings and commitments made with farmers are followed through. This can often be in conflict with other commitments made for the researcher by either administrative staff or national level directors, often on very short notice. The importance of this becomes apparent if we look at the case of Caisan. It is a minimum of 1 hour to the nearest town with a telephone and 2 1/2 hours one way to the regional IDIAP office in David. Just to cancel or reschedule a meeting by phone requires losing most of the morning.

At the very beginning of any project, it should be made clear exactly to whom each staff member is responsible. In the case of personnel seconded to the team it is recommended that they report directly to the team leader while keeping their original superior informed via copies of reports, memos etc. It may be worthwhile to try and insulate researchers in isolated areas from so many meetings; although researchers are often unwilling to forego the political visibility of staff meetings.

Uncertain Budget

A problem not uncommon to research settings throughout the developing world is the reality of uncertain budgets. While all three of the projects were designed in a period of relatively certain budget support, the last 3 years have been particularly tough as IDIAP's national budget has been cut between 3 to 5 times each year. This is compounded by the inability of IDIAP's administrative structure to manage the budget in such a way as to provide the funding stability and flexibility necessary to support FSR/E researchers in the field. In September of this year, IDIAP researchers in Chiriqui had only received 20% of their programmed budget allocation.

In an FSR/E project this becomes crucial as the entire structure of the project depends on very complete planning as mentioned above. Such aspects as timeliness of plantings, carrying out commitments to farmers or presence on the farm at harvest are crucial in order not to lose an entire year.

The 2 projects (Bugaba and Baru) that had substantial outside funding that was controlled by the residents and not the national comptroller, were able to avoid many of these problems. By using their funds early before the national portions became available, planting was not usually too delayed. Unfortunately, this potentially created jealousies in other researchers and a complacency in project staff and national administrators.

Many of the resources for FSR/E projects throughout Latin America have come from outside donor agencies. As we attempt to institutionalize these projects in national research organizations it is important to remember the limited resources (both financial and administrative) of these institutions and their mandates to produce technology for development. Thus, the criterion for budget models should be based not on what would be desirable to know but on what is the minimum required to obtain validated useful results. In this light IDIAP has used the concept of a "restricted systems approach" such that the research focused on the priority production system and did not attempt to fully quantify all production activities of the farm. This does not imply that the research was isolated or did not recognize the interactions with other subsystems.

Cost Overruns

The original budgets for these projects were developed using experiment station models. These have proved inadequate as our costs have consistently been 2 to 3 times higher than anticipated. Factors that have contributed to this include:

- difficult communication,
    - * no phones or radios,
    - * repeated trips to farms,
    - * use of vehicles to simply deliver messages,
- high vehicle maintenance costs (poor roads, etc),
- need for contingency supplies due to distances,
- expensive support services (photocopies, equipment repair),
- high transport costs.

Thus, while FSR/E can be extremely productive it is NOT cheap and shouldn't be initiated as a cost cutting measure as has been the case in some instances in the past where researchers were sent to work "on-farm" because no resources were available at the experiment station.

Linkage with Experiment Stations

All to often "on-farm" research is presented as an alternative to "experiment station" research. In fact, to be successful a FSR/E program must integrate both in a complimentary fashion. Each needs the other to

efficiently affect change. The success of all 3 projects was in large part due to the availability of tested technologies either developed on the experiment stations or existing in the literature (planting in rows, etc.) waiting to be adapted to the small farmer environment. Future and continuing improvements in the 3 areas will require the products of successful research programs at experiment stations or research on farms by discipline specialists. At the same time, the FSR/E field staff often have the data to identify the limiting factors that would be the most fruitful areas of experiment station research.

In Panama, we have not been totally successful in developing the desired linkage. The maize breeding program in Caisan is perhaps a successful example of this coordination. More commonly, feelings of competition and jealousy between experiment station and FSR/E project staffs have been exacerbated by tight money and institutional problems of a more general nature (i.e. lack of timely provision of research funds). Attempts to coordinate regular program meetings have helped somewhat. Also, in the case of the dual-purpose cattle project, by making the computer bought with project funds available as possible to experiment station staff, some informal connections have been reinforced.

Linkage with Other Agricultural Sector Institutions

In order to be truly effective in stimulating positive change in the small farm sector, research institutions need to be tightly linked with the extension services and the credit sources. In Panama, the original projects were developed solely with IDIAP. This led to occasional situations confusing to the farmers. In Caisan, for example, bank and extension agronomists continued to give fertilizer recommendations at odds with the results of validated on-farm trials. Several agreements were worked out late in the life of each project but they were usually short of the ideal.

For the future, efforts are being made to involve bank and extension staff in the actual research process. In most cases they will be local agents seconded to IDIAP for a defined period of time. This is not, however, universally attractive as there are added costs of training and replacement. We feel that these extra short term costs are essential if indeed there is to an effective institutionalization of the FSR philosophy in technology development and transfer by all agencies in the agriculture sector

CONCLUSIONS

Many of the problems discussed above are the result of the relative infancy of the FSR/E philosophy, indeed all three projects had as their primary goal the development of an operational FSR/E methodology. In the case of the Bugaba area, essentially the entire operational methodology had to be developed at each step, as there was no prior experience in this approach to cattle production systems.

While Farming Systems Research and Extension is extremely useful as a theory of applied research, it should not be applied as a cookbook. Our experience in 3 different projects shows that it can be a very effective research tool when:

- Research programs are developed with sufficient insulation from national politics to minimize the effect of personnel changes at the national level, while maintaining an ability to respond to the real needs of the nation,

- Administrators and researchers anticipate the planning and coordination needs of a FSR/E project and assign appropriate staff and support for a sufficient period of time,

- Researchers in an area have a clear view of the production system priorities and the relative role of national priorities,

- Administrators and researchers anticipate the real budget needs and expressly state that the value of the FSR/E merits the investment,

- FSR/E field researchers are cognizant of the needs to show concrete results in the shortest possible time to justify the costs,

- Institutional staff consider the importance in area selection of agroecological zones so that experiences gained in one area may have as wide applicability as possible,

- Projects truly integrate FSR/E teams both within and across institutions.

We feel strongly that the dual charge of generating and transferring technology can be made to function well in the short term using FSR/E. The long term success will depend on the amount of continued resource, political and psychological momentum that projects and programs can generate.

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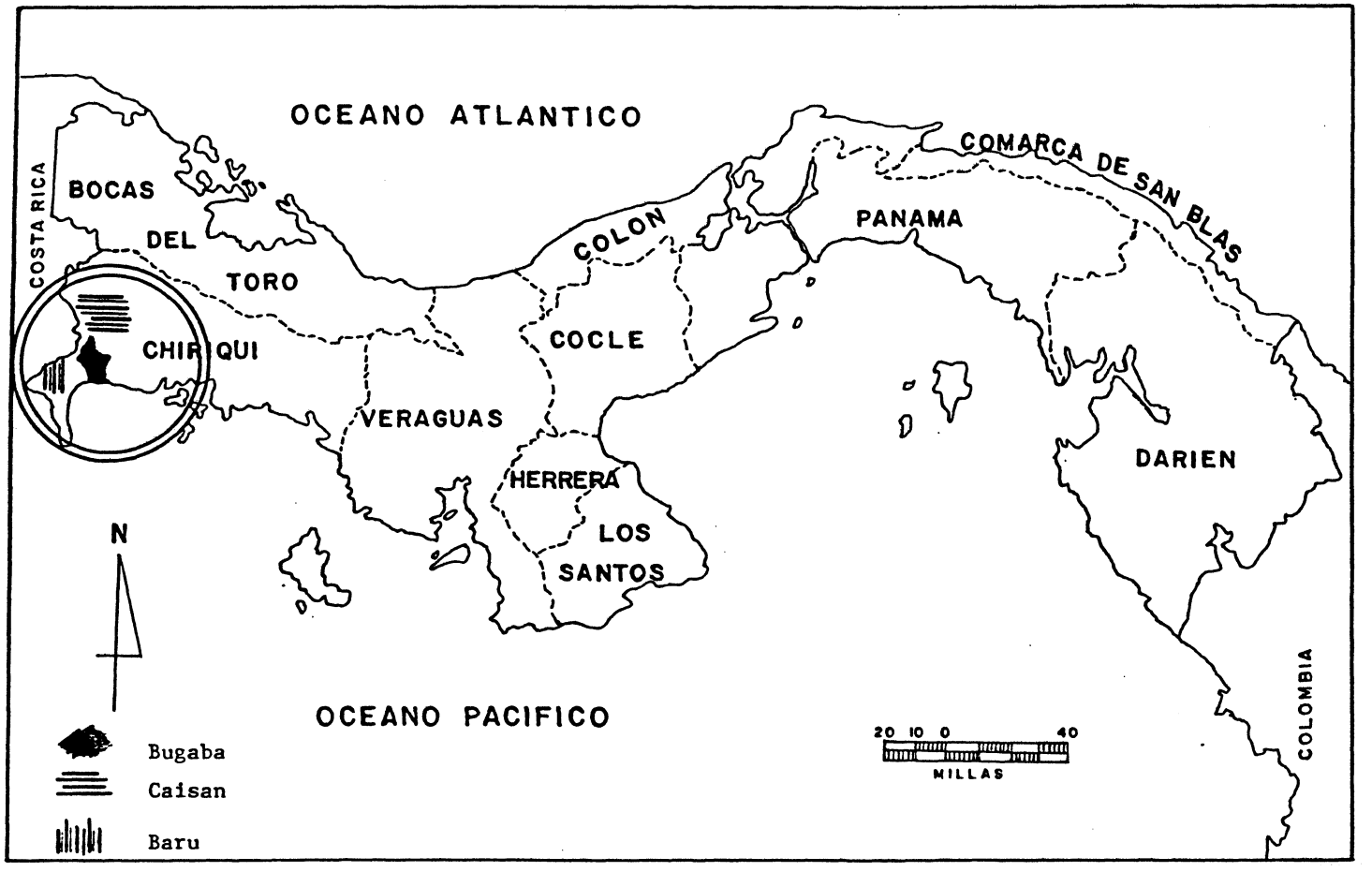
FIGURE 1. LOCATION OF PROJECT AREAS



Making the Mixed-discipline Farming System Model Work: Issues and Management Insights from U.S. and Egyptian Projects[1]

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Overview

In this paper we consider the mixed-discipline Farming Systems Research and Extension (FS R/E) model in terms of major management issues that must be dealt with and ways of dealing with them. Our approach begins with field and management conditions which have lead to mixed-discipline models, and with characteristics of the models influencing management patterns. Particular attention is given to teamwork, which is central to project success. We then consider rural development project teamwork in two empirical case examples, one international and one domestic. Finally, we discuss management insights from these cases and consider their implications for project effectiveness.

The conditions, aspirations and internal dynamics of the FS R/E project is our basic level of systems concern. To understand its problems and potentials for development, however, we also consider it in the broader, interfacing systems context, which includes the "host" system of our constituents and their environment, as well as the systems within which our sponsors and academic peers operate. Throughout, the underlying management theme involves the recognition of both the ideals and the realities inherent in development project work and how these must be balanced for effective action.

Management Conditions, Options and Challenges

In rural development efforts, as in all things, success requires both commitment to ideals and acknowledgement of the realities involved. Management, most generally, involves the ways people approach dealing with diverse ideals and realities in their coordinated activities. Ideals provide us goal-oriented guidance and justification for our efforts. Understanding the realities with which we must work--both opportunities and limitations--enables us to effectively plan and implement the means for achieving our goals. While honoring ideals and recognizing realities are essential complements in development work, in practice they often seem competitive. This is especially so in complex situations which involve the crossing of normal "boundaries" of life, as with cross-cultural work and mixed-discipline teamwork. Knowing how to maintain balance between our senses of ideals and realities is the first key to the development of team success. This partly involves compromise when necessary and planning that makes them compatible whenever possible.

Compromise and planning, in turn, depend on our having a shared definition of the situation, which includes basic agreement on goals, the means for pursuing them, what constitutes success and how well we are progressing toward it. Most basic to our achieving such agreement are matters like: our ability and willingness to view the situation in its real-world breadth and complexity; our recognition that various persons' views of the situation are legitimate and important for understanding and affecting it; and our preparedness to work together with others toward mutual achievements that surpass what we could manage alone. Insofar as problems occur in any

of these regards, they reflect conditions of our training and selection for project work, project leadership and organization patterns, and personal characteristics such as commitment, selflessness, private agendas and style. All of these are aspects of the management challenges with which we deal here.

Project Management Frameworks

The basic way in which projects prepare for the management of such challenges is in the choice and organization of their approach to work. These options are summarized by several forms or models of projects. They are best understood as ideal systems of organizational themes that should be selected and modified to fit with the realities of project circumstances. The most familiar distinctions for most of us are three organizational models: disciplinary, multidisciplinary, and interdisciplinary. The terms do not enjoy clear, consensual usage among scientists, but most often they are used in the following general ways:

Disciplinary refers to work following the established orientation and procedures of a particular academic area. Discipline standards of proper working purpose and procedure, which are presumably understood and accepted by participants, provide working guidance. This enables its organization to be typically informal and egalitarian, with one or several senior members holding nominal authority and responsibility for accomplishments. It provides an efficient way to approach fairly focused topics within the discipline's accustomed sphere of work. Its management challenges are usually associated with limitations of discipline development and over-extension of discipline competence on complex topics, requiring attention be given to further development of skills and knowledge. Its success is judged primarily in terms of the quantity and quality of output according to discipline standards and the extent to which new knowledge and procedures serve the growth and image of the discipline.

Multidisciplinary refers to dividing up complex topics into components suitable for disciplinary treatment, and then later assembling their separate but presumably complementary results for a composite multi-dimensional perspective. Management patterns of this organizational form are typically heirarchial, centralized and dominated by the standards and coordinative authority of one or several similar "lead disciplines" traditionally identified with the project's subject matter emphasis (e.g., efficient irrigation, improved crop yields, etc.). Its organization and operational procedures are usually formulated at the beginning and followed without much modification, with a designated "director" responsible for formal coordination and empowered to introduce changes in response to management problems. Its strengths are in efficient management of complex systems research crossing disciplinary boundaries which do not require unconventional approaches for the disciplines involved. Its major management challenges focus on ensuring coordinative relations among discipline staff and with outside authorities, especially insofar as these involve differences in orientation on appropriate goals, the means to achieve them, and the allocation of authority or autonomy between and within components. Its success is judged primarily in terms of timely, tangible outcomes from the perspective of sponsors and other clients being served.

Interdisciplinary refers to work which combines the inputs of persons from different discipline orientations into simultaneous sets of mutually-supportive team activities. The model typically is designed as a decentralized effort wherein sub-project teams containing complementary disciplines

focus on aspects of a task or problem in a fairly free and flexible fashion. More emphasis is usually put on cooperative processes of creative work than on conventional disciplinary standards or formal structuring of relations among participants. This enables projects to evolve a particular management form that best fits their particular circumstances (which often varies within a project). Coordination among teams and levels usually involves a mixed-discipline policy and planning group who hold responsibility for implementing the various aspects of work, and a designated project "coordinator" with whom they work closely, who nominally holds overall management responsibility. "Management" in this context is usually considered facilitation, encouragement and mediation rather than direction. Leadership is usually selected for breadth of relevant interdisciplinary knowledge and flexible, congenial interpersonal relations skills. Major management challenges focus on obtaining voluntary cooperation or compromise within and between project teams and levels; ensuring adequate information flow down, up, across and outside project units; and promoting and supporting creativity among staff, which includes justifying unconventional work from a disciplinary or governmental perspective. The strengths of the model are in complex areas of applied work, especially those involving human development in conjunction with technical developments, where more traditional approaches have often been disappointing. The success of interdisciplinary work is typically judged in terms of its novel approaches to problem solving which produce tangible short-term results for intended public benefactors and the promise of continued longer-term results through the establishement of new working procedures and relationships (which are usually harder to document than the accomplishments of other project forms noted).

FS R/E literature seems to favor the interdisciplinary form of project organization. The interdisciplinary model is seldom found in pure form, however. Most projects that are called "interdisciplinary" are a blend of all three forms making them consistent with the mixed expectations they and their staff face. None of the approaches are generally and inherently superior to the others; rather, each is best suited to certain kinds of challenges and conditions, and each carries certain limitations and problems. Given these differences, the most appropriate model (or mixing of them) is that which best corresponds to dominant conditions in the particular case. In addition to considering particular field conditions, we should consider relevant conditions in the greater systems with which they interface.

Expectations in the Larger Context of Projects

Conditions of project management involve the reality of differing ideals and concerns among principle groups who should be satisfied with the work. Many management challenges result from some personnel giving emphasis to views of one or another group with which they identify more strongly, and also from what is often a practical impossibility to fully satisfy all relevant expectations when they are inconsistent. The major expectations of relevance to FS R/E projects are those of governments, rural citizens and universities.

Governments of all forms have the responsibility to coordinate a range of activities and resources in support of various social goals, the major of which are order and security. Their operations are oriented to the presumed needs of the whole population they serve and to challenges that are not manageable by other parts of their society or state. Because the setting

they address is highly complex, their officials depend upon insights from people with special experience and knowledge, enabling vested interests to have disproportionate influence. As with all governments, the foreign governments with which we deal are receptive to technical and financial support, but not to interference in their internal operations or their people's way of life. In our official relations with other nations, we want our interests to be served, and, under most circumstances, this involves putting congenial, cooperative relations before any other influences we may have on them--particularly, any destabilizing ones. All governments are preoccupied with their ability to control circumstances of stability among their people. Developmental change processes can threaten these.

The citizens we seek to benefit with project work, in contrast with governments, see outcomes primarily in terms of their individual family's and community's welfare. Citizens often see their interests in competition with those of others, and, implicitly, with government policy. They often seek change in the way government operates or greater freedom from official policies. Accordingly, they are often distrustful of government sponsored projects and the "experts" they bring to change or control local people, and who they frequently feel do not adequately understand local circumstances. What rural citizens tend to value most is security, status in their community, greater returns on their labor and financial investments, less arduous conditions of labor, and personal autonomy. From development projects, they hope for an ally in their daily struggles, personal respect, and proper actions in terms of their traditional sociocultural system values.

Project expertise normally comes from universities that have various practical interests in participation of their staff and students, and an uncommon management form. In general, universities are a federation of rather autonomous disciplines that view the world somewhat differently. Although all are committed primarily to acquiring and dispensing knowledge, they emphasize their own discipline's perspectives and interests, according to which their personnel are judged and rewarded. And they tend to be competitive with other disciplines for university funds and influence. University officials must obtain reasonable unity amidst this diversity while ensuring that obligations to the state and to science are honored and funds for it all are forthcoming. Universities tend to define their goals very broadly, consistent with their major disciplines' interests, and to leave ambiguity about priorities among them. Few disciplines give much emphasis to public service and applied research activities; faculty who do so usually lose professional status and rewards. If the service mission is ignored, however, the university loses credibility in the broader political arena. Thus public universities acknowledge a direct public service responsibility, but give priority to indirect service through discipline research and teaching.

Farming Systems Research and Extension Ideals

Ideas introduced so far are not new to advocates of FS R/E and similar mixed-discipline approaches to rural development work. As we address these and related issues, however, it should become apparent that their implications go deeper into the processes of project management, teamwork and team success, than we often realize. In this analysis, our guidelines largely come from these FS R/E emphases (Shaner, et al., 1983; Oasa, 1985):

A. We must define a manageable, complete system context for immediate, short-term study and action (usually the small-scale family farm and household operation) while considering the effects of the larger, external

systems of relevance (markets, labor supply, finance, other agricultural inputs and policy) that are taken as "givens" in the short-term and subjects of indirect actions like policy recommendations in the long run.

B. Problem identification and remedial study is done at least partly under actual field conditions, as on farms, with active involvement of those who are to benefit, so that they, as well as we, learn from the process.

C. The primary purpose of the activity is to provide people at the "grass roots" level with practical benefits of applied research that are oriented to their "felt needs" and resources, and, only secondarily, to provide "academic" knowledge, which largely concerns the processes for being effective in FS R/E work.

D. The procedure involves flexible and timely actions by a team of complementary discipline representatives who, at least in part, work together to ensure that relevant system features are addressed so that the target system undergoes balanced change.

General Issues for Farming Systems Project Management

Approaches that carry names like FS R/E emerged in response to the recent realization that "traditional" rural development efforts often did not produce the broad or lasting results hoped for, despite considerable investment of time, money, technology and talent. This was particularly so among the less developed of "third world" and domestic farm families. Scholars like W. F. Whyte (1982) have commented on this situation: (A) we have emphasized what we know best--agricultural technology and modern infrastructure development--while being insensitive to resouce limitations and cultural traditions of our constituents; (B) we have largely addressed the "progressive" farmer, while ignoring the greatest numbers: the poorest farmers and their families; (C) we have taken too narrow approaches, trying with specialized technical expertise to impose particular new features into peoples' farm operations and lives in too short a period of time, giving inadequate attention to encouraging general, largely intangible developmental processes and attitudes that alter the general life of a system gradually and in balance; and (D) our motives are suspect in that we have often been more interested in benefits for ourselves, personally and nationally, than for the improved welfare of our constituent farmers.

Such concerns have led to the FS R/E approach, with its emphasis on mixed technical and social science teams serving small-scale farm families' development interests in ways that involve their participation, and take basic guidance from their knowledge, resources and preferences. Because the approach departs from traditional development concern with infrastructure development and specialized transfer of "modern" technology and knowledge to receptive persons with means to adopt them, it has made many U.S. and foreign development experts uncomfortable, skeptical and slow to convert to the FS R/E perspective. Thus, FS R/E emphases are far from dominant in world development circles, and, at best, serve to complement traditional approaches in areas of their omissions. The reasons for this are central to our position:

A. Traditional approaches are logical and comfortable for U.S. development professionals because they fit the traditions of our national system and feed our expert egos. But they are often ineffective elsewhere because they do not fit circumstances there, nor do they appeal to egos of the average person we target as "underdeveloped" (the foreign exceptions are higher status officials and their friends who identify with the "developed" world, seek status and tangible benefits for their nations and themselves,

and therefore embrace modernization approaches).

B. To increase the effectiveness of rural development efforts among average people who happen to be unlike us, we have begun arguing that we must tailor work to their realistic circumstances and concerns, and include them as participating partners in the process. But this produces a project model that does not fit well with the realities of our own context, a context we cannot easily ignore. Particularly relevant here is the disciplinary emphases in our training and career accountability, and our sense of special interest, be it personal, institutional, or national.

The FS R/E emphasis on limiting efforts to manageable aspects of manageable "domains" makes good practical sense. We shall ignore the issue sometimes raised by antagonists that "basic" development issues like societal injustice patterns and unequal access to development resources cannot be adequately effected at the small-domain level; that, presumably, remains for other kinds of development efforts to address. But we should not ignore a similar issue: small systems like family farm operations and local communities are elaborately linked to larger societal and international systems that tend to dominate "grass roots" affairs. When target areas are relatively remote and ignored (that is, are less linked to larger systems), the FS R/E model seems to work best. But when target areas or topics of attention are of greater "centrality" and concern in the affairs of nations (that is, more linked to these systems), power actors are more apt to direct resources to their development, and to carefully control--even add to--the linkages that exist. Under such circumstances, one cannot ignore dominant influences coming from outside the local domain, and to try working around them often means there are few remaining avenues for significant action. Confronted with such a situation, either some effort must eventually be given to exerting counter-influence through these linkages, or else the FS approach should, realistically, be avoided.

These points suggest that external conditions and opportunities must be understood and accepted as we undertake the choice of manageable development approaches, target areas, project goals, staff, and working procedures. Importantly, the FS R/E project team works mainly at the local point of intersection among external linkages that affect the target domain and its people. Further, the project team brings to the situation complicating linkages of their own, like disciplinary, university and funding agency expectations. This produces a very complex, delicate set of conditions in which team members must play out their various roles, some of which are competitive or contradictory.

As we become weary or overwhelmed with the diverse challenges in these intersecting realities, we turn to our own professional and personal ideals for guidance on priorities and assurance that there is reason to carry on. When we do so as individuals, we often reach conclusions different than our team collegues. As we attempt recourse to ideals in the collective team context, as in planning and strategy meetings, tensions are likely to emerge when differences in disciplinary and personal perspectives become apparent. Neither contribute to team integration.

On such occasions, the stage is set for power plays and reliance on authority where status differences occur. Insofar as power and authority on development teams is based largely on person's positions in, or relations to, external systems (of which we have noted there are usually many), patterns of responsibility for leadership are typically complex and unclear. Accordingly, individuals' responsiveness to leadership is usually on the basis of agreement about ideals, personal loyalties, practical convenience

and/or personal advantage. Under these circumstances, the exercise of authority or power consistent with the particular ideals of leaders or some staff is usually more divisive than it is settling for the team.

Practical Issues

These conditions introduce issues central in the practical challenges of development project teamwork. For our context, these include:

1. ***Differences in personal background*** (like discipline training, nationality, prior project experience and previous positions) make for different configurations of ideals and definitions of relevant reality on project teams. These lead to practical problems of colleagues not sharing or understanding our assumptions, terminology, procedures, etc. Further, individual participants often re-order ideals and redefine reality in response to changing project and personal circumstances. Thus, agendas and commitments vary within teams and individuals.

2. ***External expectations*** for team accomplishments are often diverse beyond reason, which leads to many of them being competitive or contradictory. To promote team member commitment to project accomplishments in general, and to avoid conflicts about ideals, project goals are usually set to include the range which various participants feel to be important, and these tend to be left openly unprioritized. Thus, clear, consensual criteria for monitoring and eventually measuring project success are lacking. When time pressures for accomplishments and limited resources get factored into the picture, competitive rather than cooperative conditions of teamwork are established.

3. ***Team expectations.*** Most participants on project teams invest their effort consistent with the ideals and skills developed during their disciplinary training, and favor doing things that they know best. Further, projects by definition are temporary activities. Concerns for career success keep team members sensitive to expectations of significant others outside the team--usually discipline, university or government agency peers and superiors. Unfortunately, these people often have little knowledge of working conditions or concern with team goals. The diffuse nature of accountability systems for development projects and personnel usually combine pressures to honor discipline standards, project operating procedures, home university or agency conditions and aspirations, and funding agency, home and host government rules and hopes. There are also expectations and rights of our target population to consider. Ironically, they are often not addressed in the formal accountability system, raising questions of how important service to them is from the system's perspective. When criteria for successful work are varied and often circumstantially defined, team members are faced with the dilemma of where to invest the sustained emphasis on which accomplishments depend. Team members differ in their personal decisions, and many undergo day-to-day changes.

4. ***Leadership and authority.*** While project authority should ideally serve to diminish these dilemmas, the reality of the average project situation makes this unlikely. In part, this is because leaders are subject to the same dilemmas noted for other team members. Further, "professional" members of the team (by definition, those capable of and entitled to make independent decisions based on relevant expertise) need latitude to exercise their judgement and creativity. Accordingly, they usually have little patience with "interference" or lack of support from leaders or others who do not share their particular expertise. In a practical sense, leaders are severely limited in their ability to exercise their authority without

jeopardizing team member's creativity and commitment. Yet they remain officially responsible for project accomplishments. The most important of their managerial attributes thus becomes broad-based knowledge of various disciplinary and personal characteristics, and strong skills at mediation and the promotion of cooperation. Persons who have these attributes frequently lack other criteria like the prestige professional credentials that play an important part in job selection.

5. *Uncertain working conditions.* Innovative development work is filled with uncertainties when it is complex enough to justify mixed-discipline teams: we are expected to work beyond the edge of comfortable conventions and secure routines. Despite our training and prior experience, we lack much knowledge of what is happening in given situations, how we can influence it, and what the consequences will be. There is seldom time and other resources to know all we would like to. Thus mistakes are bound to occur. The resulting sense of ignorance, loss of control and embarrassment are not things professionals enjoy. Inevitable errors often lead to personal defensiveness and the laying of blame, both of which are detrimental to team processes. They also prompt persons to retreat into the safety of disciplinary routines which may contribute little to innovative teamwork or constituent service.

6. *Personal agendas.* All of us deserve and benefit from personal interests such as family relations, leisure activities, investments and acquisitions, etc. Most development team professionals put personal interests in the background of their concerns as long as they feel satisfaction with their work environment. When we become highly frustrated with competing job expectations, uncertainties in our working conditions, confusion about goals, loss of control over our efforts, signs of weak support from peers or superiors, etc., it should be expected that we will retreat into our personal world with all of its' ideosyncracies. This may temporarily keep us from being disruptive of team processes, but it costs our expected contributions to the common effort. Whenever matters of personal interest and differences in personal style interfere with team progress, resentment and divisiveness emerge in team relations.

Various dilemmas, then, converge to produce management challenges for rural development teams. Consideration of how they operated and were handled in several actual cases illustrate some management options.

Case Analyses

We turn attention to team management problems and procedures in two sample rural development cases. One is an international irrigated agriculture project, and the other a similar domestic project. Both approximate the FS R/E approach. Space does not permit many specifics as background, or many dimensions of teamwork to be analyzed, but the following are some of their major features.

The Egypt Water Use and Management Project

In 1977-78 a relatively large, well-funded project began in Egypt that had the general goal of improving small-farm family socio-economic welfare through better irrigation and related agricultural practices. It also was to provide Egyptians training and experience with a project approach that closely resembled the FS R/E model. The project was a joint AID and Egyptian government effort that for eight years worked with farmers and local officials in three rural target areas.

Work was coordinated from a Cairo main office in the Irrigation Min-

istry by a senior staff of Egyptian and U.S. professionals. They represented the disciplines of civil and agricultural engineering, agronomy, economics and sociology. A senior Egyptian irrigation official directed the project along with other activities and was supported by a U.S. irrigation specialist who was technical director and chief of the U.S. party. Field teams in each of the three rural areas were composed of young, predominantly Egyptian staff from the same disciplines. Each site had an Egyptian team leader and U.S. assistant leader (both were usually irrigation specialists). There was also a U.S. support component based at C.S.U. that consisted of a campus coordinator, an interdisciplinary planning and coordination (P & C) committee, and part-time technical support staff located in various academic departments. The campus coordinator and a number of the P & C committee had originally designed the project and maintained funding liaison with AID/Washington.

The project's actual operational structure was complex and often confusing (Knop, 1981). It was designed as a decentralized, egalitarian interdisciplinary project, but operated as a part of the highly centralized and hierarchal Egyptian government where irrigation engineers were dominant. Further, the main office staff was organized and operated in discipline subunits. Therefore, the core of the project functioned in an awkward blend of the multidisciplinary and interdisciplinary models in some ways, while in other ways it sought to honor its egalitarian interdisciplinary intentions. The field staffs, on the other hand, were organized and tried to operate as interdisciplinary units. They were ostensibly given considerable autonomy to work with and take much guidance from local farmers and officials. Yet these young professionals usually had origins and futures as government officials or academic scholars, and they felt obliged to take guidance and approval from their particular discipline superiors in Cairo. The rights of a high-level Egyptian advisory committee and of the U.S. support component to provide direction for project work were never clear, but generally were exerted through strong influence rather than authority.

Project work was preceded by several months of U.S. orientation and training for all Egyptian staff except the highest of irrigation officials. All new Egyptian staff underwent similar training as they joined the project. U.S. staff received several weeks of orientation to Egyptian conditions and U.S. regulations before going over. Once in place in Egypt, the project generally followed these phases: (1) a six month problem-identification period in each field site as sites were added in sequence; (2) a work-planning, focused study and experimental "search for solutions" stage that lasted another six months to a year in each site; (3) a combined experimental intervention and extension phase that lasted until near the end of the project in each location; and (4) a brief review and policy recommendation stage at the end of U.S. involvement. Basic project work continues as an expanded Egyptian government activity that will receive some direct AID technical support.

Overall, the project has been judged by most observers as a successful one that achieved most of its goals. Of course, it was not without problems that cost it some potential accomplishments. We shall concentrate on those problems, and how they were managed, to learn what we can from the situation. From our perspective, the major problems were:

1. ***Tensions between disciplines.*** There were misunderstandings and tensions between some disciplines at the main office level, particularly concerning the propriety of, and boundaries for, traditional disciplinary work as contrasted with innovative joint teamwork. Misunderstandings and

tensions were generally not problematic between nationalities.

2. *Goal Confusions.* There were uncertainties and disagreement about project goals and where emphasis should be put, which often reflected differences in disciplinary perspective.

3. *Ambiguous authority.* There was confusion about who held what authority and prerogatives, and whose expectations within and outside the project should be honored or emphasized and under which circumstances. Related, there was confusion about how much autonomy staff at various levels did or should have to pursue their conceptions of worthwhile work. In both contexts there was uncertainty as to whether the project was to run on top-down or bottom-up guidance (or some combination of the two) and, specifically, how active a decision-making role could and should be played by cooperating farmers and field team members who were their intermediaries. Also, there was confusion about whether Americans did or should have authority in this Egyptian government operation. Most Americans did not expect it, but many Egyptian and some U.S. support staff thought it desirable.

4. *Equity.* There was status-consciousness and sensitivity among some staff about what they considered unequal treatment, especially between disciplines.

5. *Personal interests.* There was periodic preoccupation with personal interests at the expense of team progress. This took several forms, including: some young Egyptians wanting to maximize tangible benefits of participation, particularly with bonus money and opportunities for U.S. travel and education; some U.S. staff emphasizing leisure, family and expatriot community activities; and some Egyptian and U.S. staff concentrating on disciplinary research or professional contacts that would enhance their career futures.

In fact, far more was done right than wrong with the project. It was a mixed-discipline effort dominated by congenial relations and mutual cooperation among colleagues. At the field site level, most was done with the willing support of others from all disciplines. Staff at all levels were trained in, and most voluntarily sought to better understand, others' perspectives and methods as well as interdisciplinary processes. In general, those in authority used it perceptively and with sensitivity. These things largely account for project success. When inevitable challenges arose, as noted above, they were usually addressed with concern and creativity. Therein lies much of the instructive nature of this case, to which we shall return.

The San Luis Valley Research and Extension Project

Near the conclusion of the Egypt project, a number of its former C.S.U. staff sought to establish a similar "back-transfer" project in Colorado for purposes of training and further development of procedures. The site chosen was the poorest area of the state, a high arid valley in remote south-central Colorado, settled early by Hispanics and Mormons, and later by refugees of the southern plains "dust bowl". Modest funding was pieced together to provide field expenses and assistantship support for five graduate students who would work as a Summer field team and on campus during the year. Minor support was also obtained for an equal number of faculty who were to help plan and coordinate project activities. The disciplines represented included agricultural engineering, economics, agronomy, sociology-anthropology and civil engineering. Importantly, the new project was not subject to most conditions of hierarchal administrative control that the Egypt project had been. Therefore, it was designed and has operated rather

much as an egalitarian interdisciplinary project. Its activities focus on applied research and extension in cooperation with area farmers, extension service personnel and others. In addition to serving the interests of small farmers in the area, the project is intended to provide field team training and thesis materials for the graduate students. As well, some funding carries expectations for professional publications on the process and on research findings.

Preliminary project development was done through: (1) a series of campus and field meetings involving the student team, supporting faculty and extension personnel; (2) student teamwork in a FS R/E academic course which most of the first field team attended together; and (3) proposals for funding and related documents drafted by individual faculty members and faculty groups.

In general, the fieldwork approach corresponds to the FS R/E plan (although the term is avoided to ensure no presumptions of an agronomic dominance). Early activities included analysis of secondary data and the conduct of problem-identification interviews with a sample of farmers. Based on these, the field team, in consultation with faculty and extension service advisors, formulated and refined work plans and spent a successful first summer in the field. A productive second field season has just ended. To date, fieldwork has involved rapport-building in the area, continued problem-identification, specialized studies, initial probing for solutions consistent with farmers' felt needs, and some extension activities. The project is anticipated to continue as long as funds can be pieced together.

Although the project has gone very well (mainly due to the perceptiveness and commitment of the field team) it has not been free of management challenges. The major of these include:

1. *Accountability*. There is awkward fit of the project's egalitarian interdisciplinary model with the accountability system of a university that is partly organized hierarchally and partly by disciplines with considerable autonomy and competititive tendencies. Specifically,

A. The student field team was given the major responsibility for planning and implementing work, but: they do not hold commensurate authority to act freely; they are not directly accountable for funded accomplishments; and they, as individuals, remain subject to direction by their own faculty/thesis advisor.

B. Faculty advisors are to serve mainly as technical support for the team but most have little financial support for project participation; they have shown considerable "turnover"; and they have not fully coalesced as an interdisciplinary project unit. Faculty are accountable through their respective departments for the results of funds that support their students and themselves. Departments differ in their expectations for work, but generally desire that their discipline interests and perspectives be promoted by accomplishments.

C. Several university administrators are responsible for additional project operational funds and have oversight duties, but are not actively involved in routine project activities.

2. *Mixed expectations*. Broadly mixed and basically unprioritized expectations for the project have resulted from the patch-work funding situation and an amorphous project authority structure. Specifically, some support is intended for experiential training in development team processes; some is for applied research results; and some carry the expectation of basic research publications and discipline theses. None are specifically intended for direct service benefits to farmers, although the project con-

siders that a principal goal which is partly implied in its development process training responsibilities. The mix in sources of funds, thus expectations, vary between disciplines.

3. *Leadership.* Although one faculty member is designated project coordinator, he has very little financial support or authority for the task. No other authority is assigned, and even implicit authority of faculty over students is consciously minimized. The field team itself has avoided regular leadership assignments. While all of this has benefits for egalitarian interdisciplinary team dynamics, it also contributes to confusions about expectations when there are so many, they come from various uncoordinated sources, they are subject to redefinition and change, and they are usually only expressed in response to outside pressures. The field team is often left feeling obliged to try honoring all expectations equally and well, which is unrealistic under the circumstances.

4. *Discipline differences.* While team tensions have seldom occurred over the general *importance* of respective discipline's work or perspectives, there have been frustrations about the relative *urgency* of some discipline's efforts and thus the priority they deserves. This has largely to do with the need of irrigation engineers and agronomists to coordinate work with the short cropping season calendar. Accordingly, their busiest times tend to cycle together. Since they often depend upon assistance from others, some competition between them results and there is less opportunity for them to work cooperatively. Occasionally the timing issue has led to the work of others being deferred. In reality, there are differences between disciplines on matters of emphasis among goals and procedures which have been most apparent in faculty interactions. On this project there has been some disagreement about whether obtaining specific "hard data" should have priority over general assessment of the field context. As well, most participants have greatest interest in their own work, and soon become frustrated with assisting others in routine ways while their own work waits. When other's work is not well understood, when it takes priority over or competes with personal work, and/or when it seems tangential to team thrusts at busy times, there is a tendency to be critical of it and to reduce support for the persons doing it.

5. *Personality and style differences.* Personal preferences on such minor matters as when to rise or eat, tendencies to be reserved or blunt, tidy or not, always occur among people. Because the field team has common housing, share vehicles, work and relax together, they spend most of their summer lives together, away from other friends and family. Under these circumstances, some differences in personal habits lead to frustrations which become matters of greatest sensitivity when they seem to compromise work with farmers or when other bases for frustrations run strongest.

Even with these challenges, participants of the San Luis Valley project have done an excellent job of managing their teamwork challenges. As a result, overall participation has been pleasant and productive for all involved, and the project has accomplished far more than is normally expected from small-scale, seasonal effort.

Management Insights: Project Internal Operations

Valuable lessons can be found in the way participants in processes learn to define and handle their problems. In analyzing the two cases here, we have come to several tentative conclusions.

1. *Project definition and organization.* For projects to work well, their aspirations and working procedures must correspond with their real-

world conditions: goals should be realistically set and the project's organizational model should be tailored to apparent constraints and opportunities. This implies that the realities of basic circumstances be determined first, and then the general ideals of work be defined accordingly, so that the two are complementary and ideals can be taken seriously. This may involve some compromise of what we believe is ideal under the best of circumstances, but project success and personal comfort is more likely when goals are known, understood, realistic, and agreed upon.

A. Preliminary *general* agreement on goals and procedures is usually sufficient *when* there is: common knowledge of basic conditions; opportunity for personal and team flexibility in work; and the chance for participation in goal and procedural refinements through group interaction. Ensuring these conditions and enabling a gradual start-up are important points for project leaders to remember. Insofar as certain impasses to agreement are anticipated and they are not central to the project's success, it is appropriate to separate them from main-line work, define them as auxiliary or secondary concerns, and specify how much effort and resources are to be given them, by whom, and when. Similarly, when inevitable external conditions require that competitive goals or procedures be honored, pragmatic team decisions are needed as to how much effort will be given each and under what circumstances.

B. Project organizational models (or ideal summaries of systematic working arrangements) should not only fit with circumstances, but also be *understood* by participants as a reasonable way of arranging project activities. It is unimportant that they correspond with some single "pure" organizational form (e.g., the interdisciplinary model). But it is important that they clearly define preferred conditions of teamwork, including general rights and responsibilities of participants under given circumstances. For instance, it may make good sense to propose and justify, in a preliminary way, the general conditions under which a project will try to follow the interdisciplinary model, and when and why it will follow the multidisciplinary model under other circumstances. As long as a project is allowed to emerge from some basic level of pre-structuring and to change based on its experiences and new information or conditions, it will usually fit circumstances well and be easy for participants in its evolution to understand and support.

Let us turn to some illustrations of these points from our case projects. As suggested earlier, the officially proposed goals and organizational model of the Egypt project were in some important ways inconsistent with the structuring and emphases of host agency government operations there. There is little reason to expect an egalitarian interdisciplinary model oriented to farming-level practices would work well in a setting characterized by hierarchal rule and a dominant concern with irrigation system design and operation. Nor should it have been expected that changes in Egyptian agency operations could be imposed by outsiders through the design of an activity that emphasized alternative procedures and focus. The important point is not that the project plan was unrealistically designed and communicated to participants. Rather, in important ways, the project was perceptively designed and managed in that it permitted evolutionary flexibility and participant inputs from various levels, so that it could adjust to emerging knowledge of project conditions through time. Similarly, the general work plan was scheduled gradually enough to permit study and negotiation as implementation details were developed.

Further, early "lip service" to the interdisciplinary model which most

Americans and some Egyptians expected led authorities to be open to its gradual and partial realization. In time, project leaders became good at honestly communicating practical conditions which made departures from the "paper plan" prudent, and they were receptive to experimentation with project organization and operations. Both benefitted teamwork processes. As well, the occasional recalcitrance of authorities on sensitive issues served to promote team solidarity and assertiveness according to the "outside enemy" principle of informal organization and responsiveness.

The remoteness of the majority of Egyptian field sites, together with the interdisciplinary indoctrination and organization of younger field team members, made most of their efforts go smoothly and productively. When they did not, it was usually due to internal or imposed violations of their teamwork processes. Their successes and shortfalls provided examples of the value of the initial plan of organization and procedures, and supported a partial drift by the larger project in that direction. The differences between their operational model and that of the main office did cause them frequent frustrations, however. It would have helped to have had clearer correspondence and consensual understanding of operating procedures between project levels.

In many ways, the situation of the San Luis Valley project is the converse of the Egyptian situation. At the "central" San Luis Valley field team level, operations occurred with great autonomy according to the interdisciplinary model (which in some ways the realities of external circumstance did not justify). More organization, agreement, leadership and participation from the faculty/administrative level would have cost the team some latitude and initiative, but also spared them many frustrations, provided greater focus in work, afforded a better learning situation through collaborative work with faculty researchers, and improved prospects for an adequate, reliable funding base.

Under prevailing conditions, the San Luis Valley field team has developed an impressive "situational" leadership and responsiveness process. They have avoided formal leadership assignments, but individuals take responsibility for particular tasks in equitable fashion according to their present circumstances. Further, they reassign their few functionary roles (like meeting chairperson and recorder) as often as feasible, even weekly. These practices fit well with their circumstances of equal status and their need to practice flexible, situational team decision-making. Also, it supports an efficient division of labor by capitalizing on available resources while distributing work loads, insights and learning experiences more evenly. Since no feature of their organization was initially imposed on them, they have experimented with options through the years, and evolved a very workable system for their circumstances. (In this spirit, and as a post-script, it should be noted that the team, after reviewing an earlier draft of this paper, has decided to experiment with task groups among their membership in the up-coming field season [1986], with members being assigned the coordinator of specific task areas.)

Although not problematic in this field team's case, the typical team experience prompts some cautions about situational leadership and responsiveness. These obviate team effort at reaching a long-term prioritization of goals, and can interfere with sustained focus in pursuit of given goals. They also may encourage undue expediency by those charged with responsibilities they do not cherish, and diffuse responsibility and accountability beyond acceptable limits. Situational responsiveness and leadership depend upon solid agreement about general goals and operational procedures, a high

level of mutual trust, and serious commitment to team achievements. For the most part, this team has enjoyed those benefits. Under conditions where they are lacking, however, a stronger, more consistent leadership form with authority is in order to provide guidance and mediation, and to promote and facilitate the development of these team attributes (given they are required for team performance whatever the organizational form).

2. *Friendly relations leading to mutual understanding, trust, support and tolerance of differences.* Experience in many contexts has shown that one of the most important factors that contributes to smooth, pleasant, productive working relationships is personal friendships. When people interact often and openly enough to get to know one another beyond their professional roles--as real, whole persons--they become more understandable and predictable to one another. As well, they find it easier to ignore bothersome features in one another, and are more apt to support and learn from each other.

Among people who have close contact over a sustained period, friendship is reasonably easy to promote (as is hostility, if a situation is approached ineptly). Friendship emerges best under circumstances of minimal competition, status differences, pressures to perform and defensiveness. It is catalyzed by common interest and is nurtured by common experiences. Its growing presence is reaffirmed and supported by expressions of personal concern, patience, and the exchange of favors and supportive words. Thoughtful, sensitive openness and the willingness to negotiate and compromise keeps it adaptive under challenging or changing conditions, when attempts at control are most likely to upset the balanced reciprocity it depends on. Perceptive leaders and colleagues will strive to optimize these characteristics in team relations. All participants will not--probably should not and cannot--become close personal friends; but project conditions should be managed to promote the spirit of friendly relations throughout its activities and across its levels of operation. Despite the fact that they sometimes appear to cost efficiency and compromise authority, friendly relations usually do not have these effects, and they more than make up for the effort of promoting them in group effectiveness and participant satisfaction.

Our two analytic cases clearly demonstrate these points. When the initial, small project team began work in Egypt following U.S. training, it suddenly became apparent that many of the team members did not support many of the central goals and procedures of the proposed interdisciplinary plan. (Training should not be expected to transform people.) When team tensions, competition and power plays emerged, there followed a quiet strategy to promote congenial personal relations across discipline and nationality lines through social activities and personal favors. This was probably the single most important activity in support of smooth teamwork, and thus project accomplishments. It also happened to correspond with how things are done in the Egyptian culture.

It seems a truism that good working rapport is more likely to emerge from personal friendship than from project design features, training and the use of authority. It is equally true, however, that social relations can become too intense and constant, in time jeopardizing that rapport by placing too many demands on it. By design and circumstance, friendship-promoting activities of the Egypt project were concentrated at the beginning of the project and as groups of new staff joined; otherwise they were officially encouraged only periodically (averaging perhaps once a month for holidays, birthdays, etc.) Less formal arrangements like strategic project

carpooling brought senior and junior staff across nationality lines together by neighborhoods, from which personal assistance and social visitation resulted. In time, structural changes in project operations were experimentally managed to reduce competition and defensiveness and to encourage shared experiences in the field. Importantly, as more became understood about promoting friendly relations, the same emphasis was extended to contacts with cooperating farmers, significantly improving field effectiveness of the project.

In the San Luis Valley case, the development and maintenance of friendly relations between and among team members, faculty, extension personnel, area farmers and others has been emphasized in the work of the project. Social activities, joking patterns, politely frank communications, personal favors, the use of intermediaries and other conscious attempts to increase mutual understanding and sensitivity have contributed much to the team's success. When signs of tension emerge, other activities have tended to be tabled while personal relations are addressed in the most situationally appropriate way. Sometimes temporary separation of people or activities enabled release from tensions while problems were dealt with in more constructive ways. Similarly, it has often been useful to encourage the separation of professional and personal roles.

3. *Acknowledgement of differences and "stakes" in work.* Complementary differences provide the main justification for mixed-discipline teams. As units of personal interdependency, teamwork implies legitimate differences in personal as well as professional interests, abilities and circumstances. That is a reality that deserves contrast with what a few people consider ideals of interdisciplinary work: personal "sameness" and interchangeability. Where differences occur, allowances must be made. Perhaps the most important of these is personal latitude for autonomy. On first consideration, autonomy may seem inconsistent with teamwork. Beyond reasonable limits, this is probably true, but within the limits of personal support for team goals and procedures, personal latitude is important for ensuring individual initiative, creativity and commitment. Teamwork can easily become repressive, and ultimately depends on voluntary cooperation and coordination for success.

Commitment to team goals and processes is more likely when persons' unique contributions are appreciated and their special personal interests are supported by colleagues and superiors. Within limits, this applies even when it takes them away from coordinated team tasks. If one wants some time to learn the language of the place, or to collect some data and write an article for career enhancement, or to simply withdraw to maintain one's spirit and sanity, the "felt need" should be supported by others on an occasional basis when it can be justified.

Further, teamwork involves a division of labor that acknowledges everyone is a specialist at something that is needed. With recognition of special role responsibilities--perhaps statistical consultant or peacemaker--persons feel needed by the team and will not want to let colleagues down. In short: people support teams that support them in their special personal and professional interests.

In the Egypt project case, there was ample allowance for disciplinary and personal interests, in part because the main office was rather multidisciplinary in organization, and in part because most people in Egypt give high priority to personal interests. In fact, as noted above, there was often a problem with undue emphasis on personal and discipline interests. Thus the project leadership took the positions: (A) reasonable attention to

disciplinary and other professional interests was permitted when they did not interfere with planned teamwork and others' disciplinary work (if they did, they had to be negotiated with authority); (B) special consideration to pursue personal interests was usually given when asked for and explained in advance, or justified after the fact when this was not possible, but an informal tally was kept to monitor potential abuse. A very substantial proportion of project accomplishments and staff satisfaction can be credited to the independent initiative and latitude allowed staff at all levels. Abuses seemed to occur less frequently under these circumstances than when rigid authority was exercised.

In the San Luis Valley case, the situation differed. For reasons of selection and training, the original team's members were in many ways similar and interchangeable. Further, there were only a few of them and they had time to "jell" as a unit that was interlaced with strong personal friendships. They carefully shaped work plans together and most felt an obligation to support one another during the implementation of plans. Thus there emerged a reluctance to go off in one's own direction or to appreciate others doing so, even when it was encouraged by a faculty advisor. It has taken many team members considerable time to begin to feel comfortable with disciplinary and personal-interest special work. Because their "stake" is at least as much in teamwork relations per se, most have repeatedly and willingly deferred pursuit of their own interests to help others out of a sense of obligation. These conditions, combined with joint living arrangements, have made for a very intense group experience that invites frustrations.

Had a greater division of labor, and an inclination to allocate a substantial portion of time for special interest work, been built into teamwork processes, more comfort with the situation and greater personal productivity would probably have resulted. They have coped well by situationally separating themselves and pursuing their special interests when they felt the need. But it was usually not without a sense of compromise. It doubtless would have been more realistic if the field team had been less committed to the "pure" ideal of the egalitarian interdisciplinary model, and the faculty had been more so.

Final Thoughts: External Conditions

Thus far we have emphasized what can be done within project teams to enhance their success. Attention must also be given to influencing or altering problematic external conditions that affect projects and require internal coping.

We have noted that the FS R/E approach may better fit underdeveloped peoples' circumstances than traditional approaches, but it does not fit the conditions of our universities and government as well. Since we have much evidence that the FS R/E approach is effective and efficient under certain circumstances, we should use that fact as a point of leverage in seeking concessions from and changes in our universities and government agencies that would permit its unimpeded application. The route to this end involves: (1) our educating them of the facts, supported by research data and clear reasoning, on when and why the approach is superior and why certain changes in their structure are desirable for all concerned; (2) hard negotiation for favorable working conditions when establishing projects; (3) generating a base of sustained pressure which involves allies with interests similar to our own, such as the farmers we serve; and (4) taking direct action in our other professional and personal roles to begin

change processes that we have some control over.

In these regards, several points deserve emphasis. As has been argued throughout this paper, we must be informed and realistic about the system conditions we face. Systems do not change easily or without tradeoffs and costs. They are complex in their own interdependencies, and linked with many other systems that complicate matters. They have inertia and self-protective tendencies. And the substantial power disadvantage we face when operating from outside systems we wish to affect (like governments), or from non-administrative positions within them (like faculty and students of universities), demands sober sensitivity.

Such conditions are familiar to FS R/E practitioners. Our literature and experience have taught us much about successfully dealing with them. Some of those insights are summarized above. As development process professionals, we are particularly well prepared to apply our ideas and procedures to system reforms that would let us do our rural development work with greater ease and effectiveness. To the extent that something is lacking, it is resolve to have influence on institutional conditions external to projects. This is equally so whether we are working with farmers in our field areas or with administrators on our campuses or in government agencies. Where we have linkages with other systems, we have the opportunity to have external influence through them (and where we do not have such linkages we do not have externally imposed problems to bother us).

Based on the experience of the projects reviewed here, there are several ways in which successful influence on conditions external to the projects have, and could have further, reduced internal problems.

When cooperating farmers and others are satisfied with the services we provide them, they are potentially powerful allies. Efforts should be made to ensure their high levels of satisfaction and that this is known by university and government officials who affect project conditions. Farmers satisfaction can be promoted by: (A) their having realistic expectations about how the project will serve them; (B) our having congenial working relations with them; and (C) our being effective with results. Officials can be made aware of satisfaction with our accomplishments through: (A) our getting them to the field to see activities and local satisfaction with them; (B) the results of objective evaluation research, perhaps by a third party; and (C) our encouraging positive feedback from farmers through "political channels".

Ostensibly, government agencies, universities and foundations are public service systems. In reality, however, there are questions about how serious a direct service commitment most of their officials have. Their first concerns are, logically, with the stable welfare of their own operations, which are set in a highly political context that stresses obtaining funds and accounting for them. Accordingly, it is to our advantage to plan and execute work in a way that avoids problems which might jeopardize their organization's welfare. Further, we serve their interests by providing evidence of noteworthy, novel accomplishments or approaches that will be useful in their public relations and accountabilty activities. We can also remind them of their service mission and their need for evidence of public service, like we provide for them. Since their service responsibilities are to the whole system they serve, and their concerns usually are with big issues among their constituents or special interest groups, they simply may not care much about service to a limited number of small-scale farmers in remote areas. Under these conditions, we must either find innovative ways to make our efforts appear more relevant to their broader service concerns,

or we must accept the reality that they have more general or urgent concerns than ours.

In the university context, other concerns are added. As long as universities are dominated by autonomous disciplines which competitively promote their self-interest, mixed discipline teamwork will be problematic. These conditions also produce the basic problems with which university administrators cope in maintaining campus unity and stability. The traditional justification for discipline autonomy--and university autonomy in the political context--was to support processes of independent creativity. Given present development of established disciplines, however, we now realize that greater creative promise is likely from mixed-discipline efforts and that ample knowledge is available for service applications. Both are impeded by the present structure. What we still lack is developmental experience with how mixed-discipline models can be made more workable. There are several things that could be done to improve this situation.

University governing boards and relevant legislative units should make clear their expectations for precisely defined university mission statements that provide balanced emphasis among major goals. In the land grant tradition these include public service activities. Criteria corresponding to mission statements should provide the basis for universities' funding and accountability. Such action from the top would provide both impetus for needed adjustments within the university and the realistic ideals for its justification and guidance. It also implies that administrators managing internal changes would be supported with needed authority and special transitional resources to counteract the great inertia of universities and the self-serving sensitivities of their disciplines.

Administrators and faculty involved in adaptive activities face several options for improving conditions of cooperative interdisciplinary applied work. Although they cannot realistically dismantle the disciplinary organization of universities, they can develop intersecting organizational structures like internal institutes that cross-cut discipline authority that bring together some faculty and staff, at least part-time, around common interests in interdisciplinary topics and university mission emphases. Such a transition realistically depends on administrative authority and reallocated resources.

Another option to the cross-cutting "matrix" form of organization, above, is the "stochastic" model of further dividing the present discipline structure to create new units that would function as "interdisciplinary disciplines" under present rules. Those who advocate farming systems departments favor this option. We do not. Such would further divide rather than unify the university, add administrative expense, and would not address the basic problems resulting from disciplinary autonomy and competition. If cross-cutting organizational elaboration is feasible, that seems preferable; if not, new interdisciplinary departments may be justified.

There is an emphasis implied above that would move the university in the direction of greater interdisciplinary applied cooperation without necessarily involving organizational change. Academics respond to a combination of their particular ideals and the reward structure of their accountability system. Universities now have the ability to expect and reward participation in applied interdisciplinary work, reducing the present professional penalties on faculty who would follow that course. This could be done through existing departments by making it clear that interdisciplinary applied work should be considered equivalent to traditional

disciplinary work. However, encouraging and rewarding this would probably be more easily, uniformly and honestly managed through other university channels than departments. All that seems lacking is initiative of administrators given the absence of organized pressure from outside and within the university.

Faculty interested in FS R/D and similar interdisciplinary activities hold some options that would minimize other constraints to teamwork. Principal among these are developing a better understanding of the ideals and realities of applied mixed-discipline teamwork, and teaching these to colleagues and students, so that those willing to pay the price of participation can be better prepared to do so successfully. As well, faculty who envision the ideals and benefits of such work should take initiative to collaborate with other colleagues when possible, support those who do so, and collectively pressure the university for concessions that facilitate it.

All of these options for influence external to projects are feasible in the U.S. setting. If they are not forthcoming, it is probable that universities will continue to lose credibility, thus support for and experience with newer forms of cooperative creativity and service that they are expected to perform or teach. This being the case, resources and influence will find their way to other kinds of research and development institutions that emerge to fill the void.

Those of us who work on farming systems projects cannot afford a preoccupation with universities' and governments' reform to simplify our teamwork processes. That would certainly compromise our main-line effectiveness in the short term. But some attention to external changes seems an indispensable complement for effective service to our constituents' needs, and our own, in the longer run. If we take our farming systems ideals seriously, we should also recognize this reality.

Endnote

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DEVELOPMENT OF FSR/E PROGRAMS IN NATIONAL SYSTEMS

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AGRICULTURAL RESEARCH AND EXTENSION IN FRANCOPHONE WEST AFRICA: THE SENEGAL EXPERIENCE

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I. INTRODUCTION - STATEMENT OF THE PROBLEM

The need for a close relationship between agricultural research programs and extension programs has been debated in Senegal for over 25 years. At independence, the "promotion of Research-Development" was a pillar of the government's rural development policy for the 1960s. Thirteen years later in 1973, on the eve of the creation of ISRA (The Senegal Institute for Agricultural Research), the Minister of Rural Development renewed the government's concern with Research-Extension (R-E) by convening a national conference on the most effective use of research results in agricultural production programs.[1] More recently, several international assistance agencies, including the World Bank, USAID, and the French *Caisse Centrale*, have made research and extension agreements a cornerstone of their support for agricultural projects.[2] CIRAD, the newly created umbrella organization for French international agricultural research, too, plans to redefine its Senegal program in order to concentrate on joint research and extension programs.[3]

Despite the continued concern among Senegalese policymakers with improving the R-E alliance, many of the government's agricultural policy statements do not clearly articulate the contribution and importance of agricultural research to agricultural development. Agricultural research occupies a secondary place in Senegal's four-year development plan and is scarcely noted, either in the government's 20-year review of agricultural development or the more recent New Agricultural Policy.[4] Furthermore, charges and countercharges continually fly between researchers who are criticized for non-adaptive, ivory tower research and "developers" (extension personnel) who are charged with a narrow minded productionist orientation at the expense of addressing problems identified by farmers.[5]

Most recommendations for closing the R-E gap concern improved communications and contacts between research and extension personnel. While clearer lines of communication could improve the quality of the Senegalese R-E, we suggest that the R-E structure must be transformed to promote an interactive exchange among researchers, extension personnel, and peasant farmers which assures the continued development of new technology and access to this technology by peasant farmers.

Our discussion of the R-E issue in Senegal is presented in this paper as follows: Part II suggests that the Senegal R-E experience can be most fruitfully understood as a case of institutional change. Part III provides a historical overview of R-E in Senegal, followed in Part IV by two case studies. The conclusion offers policymakers some lessons for closing the R-E gap; we also identify aspects of production systems research (FSR) in Senegal that might contribute to the sustained development of Senegal's agricultural research capability.

II. INSTITUTIONAL CHANGE - SOME GENERAL CONSIDERATIONS

Ruttan and Hayami (1985) argue that adaptation in state agencies such as ISRA occurs as a result of changes in an institution's economic, political, and technical environments. In most industrialized countries, for example, agricultural research agencies have responded to change in a straightforward manner: farmers with constraints on their land or labor demand the development of improved technology and more modern inputs in order to overcome these constraints; agricultural scientists and administrators, in turn, seek to satisfy these demands and thereby continue an ongoing process of change and adaptation.

Several conditions influence this process. Demand is usually expressed through active farmer or commercial organizations. Moreover, the research system is often decentralized and includes the appropriate incentives so that scientists and research administrators can respond to client demands and are rewarded for so doing. In many cases, if these conditions exist it is because governments and policymakers have deliberately and carefully nurtured support for agricultural research. As Ruttan and Hayami (1985) note, "the power structure among vested interest groups" usually determines the nature of the response which researchers make to client demands.

Agricultural research is commonly a publicly financed activity, since its results are publicly available. But client-oriented agricultural research does not necessarily require financing through tax revenues. Specific groups, especially plantation owners or large cash crop producers, often finance their own commodity research programs. Where agricultural research is a state activity, it can offset, as Ruttan and Hayami (1985) suggest, "serious distortions in the allocation of research resources" unless "vested interest groups" feel that the costs of change outweigh the benefits of maintaining the status quo. If this latter condition exists, "socially undesirable institutional innovations" can occur.

While Ruttan and Hayami's model deals in detail with the relationship among economic factors, technical factors, and institutional change, the role that political factors play needs to be better defined and incorporated into the analysis. To achieve this, we begin by expanding our view of the arena in which an agency such as ISRA operates, to include the international community and more specifically the assistance agencies and international agricultural institutes that help to finance and support agricultural research. These institutions form part of the structure of power of agricultural research in West Africa. They influence institutional change through their ability to withhold financial resources and goods. They also help define the demands and rewards facing research scientists and administrators. In short, they play a major role in defining the rewards and incentives for agricultural researchers.

In addition, we can achieve a better understanding of the relationship between political factors and institutional change by specifying and characterizing the "vested interest groups" that seek to influence the nature and direction of agricultural research programs. To do so requires the ability to identify and relate different actors in an overall R-E

system. For example, we suggest that in order to analyze and evaluate innovation in agricultural research throughout most of West Africa, it is necessary to identify the specific interest groups within the research community, the relationship between research and developers in the development agencies, and between these actors and the international research and assistance agencies.

Before turning to these case studies, we briefly review part of the history of agricultural research in Senegal and outline the organization and activities of ISRA's recently created Production Systems Department.

III. AGRICULTURAL RESEARCH AND EXTENSION IN SENEGAL - AN HISTORICAL OVERVIEW

In order to understand the R-E relationship in Senegal, it is useful to note three distinguishing features of Senegalese agricultural research: researcher autonomy, an extensive research infrastructure, and a tradition of research under farmers' condition.

For over 50 years, from the early 1920s through 1974, agricultural research in Senegal was in the hands of specialized institutes, most notably IRHO, IFAC, IRTC, and IRAT.[6] This permitted considerable research autonomy for their research scientists and administrators, and it has left a tradition of researcher accountability primarily to a disciplinary scientific group within a bureaucratically organized research institute or government agency.

Second, since Senegal served as the headquarters for agricultural research in French West Africa for almost 50 years, the country today has one of the most extensive research infrastructures of any Francophone Sahelian country. The Groundnut Experiment Station, established at Bambey, Senegal in 1921, became the Federal French West Africa Agronomic Research Center in 1950. Researchers operated a network of 10 substations throughout West Africa, of which three were in Senegal. By 1960, when Senegal designated IRAT to manage most Senegalese agricultural research, additional substations were already operational at Sefa, Richard-Toll, Guede, and Djibelor (Map 1). In addition, IRHO had separate facilities at Bambey and three of its own substations; other French research institutes, especially IEMVT, CTTF and ORSTOM, also managed their own substations.

By the early to mid-1960s, considerable basic agronomic work on Sudano-Sahelian agriculture had been completed. Researchers were confident that if improved groundnut varieties, better soil fertility practices, animal traction, and better cultivation practices were available to farmers, their use would lead to increased agricultural production. Many of these changes and improvements are still part of the technical packages in Senegal's rainfed agricultural production programs.

Third, the expansion of Senegal's research infrastructure noted above was due partially to researchers' demands that trials and experiments be undertaken on substations and *Point d'Appui, de Prevulgarisation et d'Experimentation Multilocale* (PAPEMS) throughout the country. Because the PAPEMs were located near village fields, they provided opportunities for farmer visits, field demonstrations, and short-term training. The development of two of Senegal's popular hybrid maize varieties, for example, started from the contacts between PAPEM researchers and peasant farmers.[7]

Researchers' concern with doing research in the "real rural setting" was also one of the key elements in the proposal in the early 1960s to establish a series of *Actions Regionales Pilotes de Developpement Integral* (ARDIs),[8] or action research programs within uniform agroecological zones. Although never established, the ARDI was a key idea behind Senegal's well-known *Unites Experimentales*. The *Unites* program made a significant contribution to agricultural development in Senegal during its 12-year existence from 1968 to 1980. Many technical recommendations were either developed or made more appropriate to the conditions of the southern Sine-Saloum; researchers and extension personnel alike gained a much better appreciation of the structure and organization of the peasant farmer family, and suggestions were made to improve the nature and management of the village level extension agents (*encadrement*). Moreover, the *Unites* program marked an important phase in the evolution of agricultural research in Senegal and is widely regarded as one of the first types of "farming systems research" in West Africa.[9]

The IRAT-ISRA *Unites* program, however, has never been without its critics: from the beginning, many researchers felt that *Unites* off-station research was not truly scientific research; extension personnel, in turn, charged that the program should have been the responsibility of agricultural extension since the program was principally action research. Among the other criticisms, including the program's cost and directive (top-down) approach to research, was the complaint that extension agencies were not formally involved in the *Unites* and thus a R-E alliance was not forged. Only informal personal contacts existed between researchers and extension personnel at the local level. By the time the *Unites* program ended in 1980, no progress had been made toward the promotion of an ongoing research and extension relationship.

During the *Unites* period, nevertheless, ISRA had joint research contracts with several agricultural extension agencies. As one condition of its *Caisse Centrale* (C.C.C.E.) financing, *Societe Nationale d'Amenagement et d'Exploitation des Terres du Delta* (SAED), was obligated to negotiate research contracts with ISRA for both on-station and off-station programs to study smallholder production problems on irrigated perimeters. Cotton research was undertaken under contract with *Societe pour le Developpement des Fibres Textiles* (SODEFITEX), and the USAID-financed Cereals Production Project in the Groundnut Basin included provision for research contracts between ISRA and *Societe de Developpement et de Vulgarisation Agricole* (SODEVA).

To summarize, off-station, farm level research related to agricultural

production programs is not new in Senegal. For over 20 years, on-station researchers have regularly pushed their programs outwards in order to run their trials and experiments under different agroecological conditions. ISRA, too, has responded to demands from extension agencies for farm level research. Assistance agencies have also played an important role by defining research programs and methodology in their project documents and by very closely supervising the execution of these programs. In addition, researchers have followed relatively independent programs and have rarely been concerned with a need to respond to farmers' constraints and problems.

The Production Systems Research Department

As part of a much larger program for reorganizing ISRA, the Agricultural Research Project financed principally by the World Bank created the Production Systems Department in 1982. The department was given the responsibility to organize production systems or FSR teams in ISRA's regional research centers, as well as manage several thematic or support research programs including bioclimatology, weed control, post-harvest technology, and soil fertility.

Since 1982, the PSR Department has launched three production systems teams in three research centers at Djibelor, Kaolack, and St-Louis, plus a multidisciplinary research program at the Dahra Center in Senegal's sylvo-pastoral zone. Each team is composed of at least an agronomist, animal scientist, economist, and a sociologist. Scientific support and management for these teams is provided by a multidisciplinary Central Systems Analysis Group composed of senior researchers based in Dakar.

Under the Agricultural Research Project, each Production Systems Team was to include a researcher/agricultural extension specialist who would fill a joint ISRA-Extension Agency position within the Extension Agency. The objective of this specialist would be to institutionalize the R-E relationship between each PSR Team and the appropriate Regional Development Agency.[10] The specific responsibilities were to include: (1) the management of all farm level tests and trials prepared by production systems and commodity researchers in collaboration with the extension agency; (2) the training of extension personnel in the use of new technology; (3) the identification of any farmer reactions to or constraints on the use of new technology, and (4) monitoring to assure that researchers were aware of these reactions and constraints.

Both ISRA and the Regional Development Agencies found it difficult to accept the specialist position. The extension agencies were not convinced that a researcher should be assigned a full-time position within their agencies. ISRA did not have personnel qualified to fill the position and, faced with restrictive personnel ceilings, preferred to guard researchers exclusively for its research programs.

In place of a research/extension specialist, ISRA proposed ISRA-Extension protocol agreements as a means to build and institutionalize the R-E relationship in the major agricultural zones throughout Senegal. ISRA and SOMIVAC signed a protocol agreement in 1983 and similar agreements

are under discussion with both SAED and SODEVA. Before looking specifically at the ISRA-SOMIVAC relationship, the following case study illustrates the advantages and disadvantages of an R-E relationship which is essentially "driven" by an extension agency and a donor.

IV. TWO CASE STUDIES IN RESEARCH-EXTENSION

1. Matam: ISRA-SAED Contract Research

Dreams and plans to harness the Senegal River and gain control of its water flow for inland transport and agricultural production date from the turn of the century.[11] Following the recommendations of a study mission in 1935, France created the *Mission d'Amenagement* in 1938 to try to offset Senegal's dependence on Indochinese rice imports. By 1945, the *Mission* had plans to develop approximately 50,000 ha for irrigated rice production. Today, SAED is responsible for irrigated crop production along approximately 600 km of the left bank of the Senegal River.

The valley, SAED's area of intervention, is commonly divided into three zones: the Delta, Middle, and Upper Valleys. Over one-half the irrigable land is located in the Delta and is composed of large perimeters (i.e., up to approx. 2,000 ha perimeter^{-1}) in which the average holding is between 1 and 1.5 ha. The Middle Valley includes both large and small (village) perimeters, while only small perimeters (approximately 20 ha perimeter^{-1} in which the average holding is .25 ha) are found in the Upper Valley.

The development of approximately 240,000 ha in this valley is one of Senegal's principal economic priorities. This land can potentially be brought into production upon completion of the Diama and Manantali dams in 1986 and 1989 respectively. SAED's ability to bring only an additional 3,000 ha per year into production, however, makes the timely achievement of this objective somewhat questionable.[12]

The research base for a major economic development program has not been laid. There has been little or no consideration of the role of agricultural research in the development of the valley, nor does ISRA have a long-term research policy for the region despite its importance for Senegal's economic future. Since WW II, agricultural research has been undertaken by several national and international organizations, with little or no attempt to coordinate their often diverse programs. Neither IRAT (until 1974) nor ISRA has ever had the core scientific research personnel to carry out more than limited research activities. Until 1981, for example, the only ISRA irrigation engineer was stationed at Bambey. WARDA has been responsible for rice research; ORSTOM has done most of the basic soils work in the region; FAO, OMVS, CILSS and CIMMYT have been variously responsible for most of the basic research on sorghum, maize, and wheat. There has been no socioeconomic research linked with the agronomic research, nor has there been any systematic evaluation of the technical package used by SAED. In sum, agricultural research in the valley has been designed and carried out primarily in terms of the interests of different research institutes and agencies. These programs may have been compatible, but they were neither

conceived nor designed to address the significant problem of long-term agricultural development planning for the region.

ISRA has undertaken several contract research programs for SAED. Varietal testing was done and cultivation techniques were studied as part of the Dagana Perimeter development program. Power hand tillers were tested in the Ndombo-Thiago (Richard-Toll) perimeters. ISRA also managed an experimental cattle production unit and a model sprinkler irrigation system at Ndiol under contract with SAED. In May 1983, a joint donors meeting (France, USAID, The World Bank), convened to review future financing for SAED, recommended that ISRA and SAED move beyond contract research and toward a closer, more reciprocal R-E relationship.

In response, ISRA and SAED held discussions on this question in October 1983, and an ISRA-SAED committee was commissioned to define the priority ISRA-SAED research questions and programs and to prepare an ISRA-SAED protocol agreement.

An ISRA-SAED research protocol has not yet been prepared, but the St-Louis Production Systems Team consults regularly with SAED in the design and implementation of its research program. Pressured by its donor agencies to show progress toward decentralization and smallholder responsibility as a condition for continued financing, SAED seeks to dominate these consultations and to stipulate the conditions of the R-E relationship with ISRA. SAED, donor agencies, and the Government of Senegal are convinced that the development of a new technical package is the key to improving smallholders' productivity. As one part of its support to SAED, the French *Caisse Centrale* earmarked funds in 1980 for an ISRA research program to help solve specific production and management problems in the Middle Valley Matam perimeters. A joint SAED/ISRA meeting in September 1980 identified three priority research themes:

- Increasing the area under cultivation without reducing agricultural productivity;

- Developing and maintaining a cost effective irrigation system;

- Testing a diverse number of crops, especially vegetables.

During a subsequent technical meeting in early 1981, ISRA resisted pressure from SAED to move quickly from on-station trials to farm level recommendations. Attention focused on several financial and administrative issues, including management of the contract. ISRA was concerned principally with resolving outstanding issues from a previous contract, receiving an advance payment, and posting a SAED technician/agronomist full-time at Matam to supervise and coordinate the research. SAED, on the other hand, felt that ISRA should provide enough researchers to carry out the contractual research.

Two years later and only under considerable pressure from the *Caisse Centrale*, the Special Agreement for Matam (*Convention Particuliere*) was signed in March 1983. The delay from the start of discussions in late 1980 to early 1983 was not due to serious misunderstandings or difficult

negotiations between ISRA and SAED, even though the relationship between the two organizations was strained. The ISRA Center at Richard-Toll was administratively unable to respond to many of the problems raised by the contract, and at the time responsibility for the negotiations was transferred to the Production Systems Department, the Department faced other priorities.

As finally negotiated, the Matam Agreement consisted of the following research activities:

- Forage crop trials (even though the 1981 meeting had suggested the use of agricultural by-products);

- Rice and maize varietal trials;

- Fertilizer response trials on rice and maize;

- Fruit tree nursery;

- Vegetable crop demonstration trials and marketing studies, and

- Water management studies.

This list reflects the compromise of donor and researcher proposals based on suggestions concerning methodology, results of ongoing research, and availability of researchers to carry out desired activities. Rice producers were not consulted and the available research results used to prepare the off-station program came principally from on-station programs.

ISRA did receive an advance payment, but the vehicles and motorbikes were not delivered until midway through the growing season, and SAED agents responsible to supervise the trials were posted even later in the year.

During the first year, all the programs were started except for the water management study, which was delayed pending the acquisition of required equipment. Six farmers participated in the rice variety trials, four in the maize trials, six in the fertilizer response trials, and three groups of five farmers each were selected for the vegetable crop demonstration trials. All the trials were designed and managed by researchers; at SAED's request, the trials were run in only one zone even though 1983 was the first year of operation for the perimeter and most farmers had little previous experience with irrigated agriculture.

By the end of 1983, only the rice varietal trials provided significant results. For logistic and organizational reasons, the other varietal trials were inconclusive; the maize trials, for example, were started 46 days late. A dispute between SAED and the perimeter farmers, which prevented the delivery of diesel fuel for the irrigation pumps, jeopardized other trials when the perimeter could not be irrigated on time. ISRA and SAED recognized that the 1983 trials had been identified and defined without any discussion with farmers and, consequently, were unresponsive to their interests. As a

result, farmers refused categorically to consider the forage crop trials because of the competition with food crops, especially since the area had been quite hard hit by drought. Farmers also were uninterested in "concentrated" stands of fruit trees, which they saw as a haven for birds.

The forage crop trials and the fruit tree program were dropped from the 1984/1985 program of work. Three rice varieties were selected for demonstration trials with a limited number of farmers, while the maize varietal trials were designed to identify the place of maize in a crop diversification scheme. Fertilizer response trials on rice and maize were continued on farmers' fields but were run directly by SAED agents or research assistants. Several vegetable variety trials were also continued in order to assess the viability of different types of vegetable production during the cool dry season. At SAED's request, the hydrological research component was designed to evaluate the technical aspects of water supply in the zones rather than to examine the problems of water management and control at the farm level.

By 1985, considerable progress had been made toward adapting the research program to the problems and constraints identified at the local level. At separate times, SAED, ISRA, and CCCE visited Matam in March 1985 to review "the real need of farmers with respect to a research program." Discussions during both visits emphasized the need to simplify trials in order to facilitate management by the SAED field agents and to improve their ability to turn the results into farm level recommendations.

Currently, during the 1985/1986 season, rice demonstration trials that combine different fertilizer response trials are underway in all five zones of the Project. In response to specific problems raised by the SAED agents during their discussions with ISRA, two tests were also designed in one zone to evaluate insecticide use and different weeding techniques. In contrast to previous years, 1985/1986 trials have been adapted and oriented to respond to specific problems raised by the SAED agents in each zone. In addition, a one time socioeconomic/opinion survey is planned for the end of the trials in order to obtain a more systematic view of the farmers' impressions of the research program.

Consistent pressure from SAED and CCCE has obliged ISRA to design more demonstration trials and to expand these trials as quickly as possible to all five zones of the Project. Farmer disinterest and opposition in some trials has led to modifications in the research program. The Matam research program has made only a tentative effort to include the farmers' point of view in the research program design. The identification of local problems by the SAED agent in each zone should not be confused with the direct identification and management of research by farmers. The effort to listen to technical agents provides at best a channel of communication, albeit imperfect, that has previously been unavailable to farmers.

2. ISRA-SOMIVAC Research-Extension Liaison Unit

The second case study, drawn from the Lower Casamance Region,[13] begins with the brief history of the ISRA-SOMIVAC (*Societe pour la Mise en Valeur de la*

Casamance) Research-Extension Unit since 1983 and illustrates a possible strategy for improving the R-E relationship.

When the Djibelor Production Systems Team was organized in March 1982, ISRA proposed a protocol agreement with SOMIVAC that would commit both parties to joint efforts to adapt agricultural research and extension programs to the problems and needs of peasant farmers. After approximately six months of periodic discussions between ISRA, SOMIVAC, and USAID, a Research-Extension Protocol Agreement was signed by ISRA and SOMIVAC in 1983.[14]

During its first year of activities under the Agreement, the Liaison Unit served principally as a forum for researchers and management level SOMIVAC personnel to discuss their respective programs. As a result of these discussions, SOMIVAC agreed to assist the PSR Team, both in defining recommendation domains for the Lower Casamance and in preparing a joint plan of work for watershed management in the mangrove swamp inlets (*bolongs*). The Liaison Unit's performance at the end of 1983, however, was judged by both ISRA and SOMIVAC to be far short of expectations. Managers and planners from SOMIVAC, rather than field and technical extension personnel, attended the few meetings that were held; and the unit's meetings rarely arrived at concrete conclusions or led to specific, coordinated activities.

In order to improve the effectiveness of the Liaison Unit, ISRA and SOMIVAC created seven small subject matter technical working groups in June 1984 to design specific and joint R-E activities focusing on priority topics and problems in rice breeding, animal traction and equipment, land use, animal production, seed multiplication, socioeconomic (production systems) studies and surveys, and agricultural inputs and agricultural policy. Currently, special Lower Casamance Project funds finance some of these programs. One principal program is the rice variety trials, which are managed by farmers and visited during the cropping season by joint ISRA-SOMIVAC teams who obtain farmers' reactions to the trials. Other major activities include testing sweet potatoes as a sequential crop to irrigated rice in selected areas and monitoring the desalinization process in two zones that have been recently protected by small saltwater intrusion dams. Here researchers will test simple cultivation techniques and rice varieties that are moderately salt tolerant; they will also undertake a short socioeconomic farm and village survey in one valley. Other joint activities for 1985/1986 include a follow up study of the use of groundnut seeders for rice, joint R-E visits to rice seed multiplication farms, and an analysis of PIDAC's special credit program among selected producers' groups (*Groupement de Producteurs*).

Training has been an important component of the ISRA-SOMIVAC relationship since 1984. SOMIVAC/PIDAC personnel participated in three ISRA PSR Department Workshops: a Farming Systems Research Methodology Workshop (October 1984); another entitled Microcomputers in Agricultural Research (MSTAT-January 1985), and a third concerning the Design and Analysis of Agronomic Trials and Tests for Peasant Farmers (May 1985).

Responding to USAID's interest in reorienting the Lower Casamance

project toward a program for saltwater intrusion control and mangrove swamp watershed management, the Liaison Unit organized a June 1985 workshop-conference to discuss saltwater intrusion dams in the Casamance. The workshop brought together researchers, extension personnel, government representatives, and delegates from farmers' organizations. The result was a direct and frank discussion of the government's preference for large dams vs. the ISRA-SOMIVAC preference for a small dams policy; the conclusions should provide a sound basis upon which to evaluate the advantages and disadvantages of the large and small dams policies.

In addition to the ISRA-SOMIVAC research activities, SOMIVAC's acceptance of the agricultural zones delimited by the Djibelor PSR Team represents an important step toward closing the R-E gap in the Casamance. Until this year, SOMIVAC defined its zones of intervention with maps and descriptions prepared by outside consulting firms. These maps and descriptions were extremely useful in regional development planning and especially in defining water management programs, but were of limited use in defining an appropriate extension program adapted to different production systems. The PSR Team's "zonification" of the Lower Casamance has been refined each year and the fact that SOMIVAC has accepted these zones for its extension program reflects the importance that SOMIVAC now gives to incorporating socioeconomic criteria in its planning. Furthermore, the PIDAC extension program now includes themes or recommendations for intensifying cropping that were proposed by the PSR Team: associated cropping with maize and cowpeas, and the sequential cropping of rice and sweet potatoes.

Under the protocol agreement, the ISRA-SOMIVAC relationship in the Lower Casamance has progressed along three fronts: joint or coordinated research activities and studies; training, and discussions and review of regional rural development policy. In addition, more technical personnel from the field participate in the Liaison Unit's meetings and activities.

The success of the ISRA-SOMIVAC relationship, however, is not due solely to the joint activities of PSR researchers and field level extension personnel. ISRA on-station researchers play a critical role through their ongoing research programs and by committing some of their research time to problems raised by the PSR Team. In other words, the ISRA-SOMIVAC experiment is significant because the on-station programs provide critical support to the PSR program and to the Liaison Unit's activities. For example, the on-station weed control program has moved from a singular concern with the chemical control of weeds to an examination of how different land preparation techniques practiced by the farmers can more effectively and less expensively control weed growth. Farmer-managed trials have been added to the varietal breeding programs, and the rice plant pathologist and entomologist have added cassava and other vegetable crops to research programs that centered predominantly on rice. The soil fertility program is testing lower fertilizer doses and the agricultural engineer has moved beyond the standard census of agricultural equipment to a review of the farmer's use of equipment.[15]

Major challenges have yet to be overcome in this R-E experiment.

Extension agents and those working directly with peasant farmers are still only marginally involved in the Liaison Unit and an effective means to include farmers' representatives (from producers' groups, cooperatives, or village organizations) in the Liaison Unit has not been found. Even though more researchers, especially those with on-station programs, and extension personnel are now ready to account for the peasant's point of view in preparing their programs, the peasant farmer is still not a full partner in the R-E relationship.

Furthermore, the interactive process of the Liaison Unit must spread from the local level to both regional and national policymakers. Both ISRA and SOMIVAC need to reach out with the news and results of their joint programs. The ultimate test of the successful R-E relationship is, of course, increased agricultural production and improved rural welfare. Meanwhile, the Liaison Unit can make a significant contribution to agricultural development by calling the attention of policymakers to the important accomplishments and effectiveness of programs designed on the basis of farmer defined problems.

Despite the Liaison Unit's progress to listen to and respond to farmers' problems, its operations and programs still depend heavily upon outside encouragement; donor agencies have provided a critical measure of support for the Liaison Unit. Such support has a limited time frame and is oriented toward specific objectives. USAID/Senegal, for example, is increasingly interested in watershed management, thereby leaving the future of the R-E unit open with respect to support for continued work on rainfed agricultural problems.

CONCLUSIONS AND POLICY IMPLICATIONS

ISRA represents a classic case of an open institution that must constantly respond to demands from its environment. Foreign aid currently pays the operational costs of ISRA's research programs, and researchers spend a significant amount of time dealing with aid agency advisors, consultants, and evaluators who solve ongoing problems, define new activities, or review the results of past programs. Foreign financing of Senegal's agricultural research will be required for many years, and aid agencies will continue to be among those with important vested interests in ISRA's programs.

Confronted with this situation, we have suggested that a central and dominant concern for ISRA researchers and administrators should be how to include the Senegalese peasant farmer as well in agricultural research. Our case studies represent two ongoing experiences, and while the balance sheets for the account of the peasant farmer cannot yet be drawn, these case studies suggest some lessons to be applied when creating a more farmer oriented R-E framework to develop and transfer technology. They also underscore the contribution that PSR can make to improving the long-term performance of agricultural research in Senegal.

Lessons for ISRA

Contractual research like that under the Matam Agreement is very attractive to ISRA. It offers ready research funding at a time when research costs are rising and financial support is uncertain. Contractual research with an extension agency can also keep research programs relevant by forcing researchers to address real world problems in collaboration with extension personnel. Consequently, it is easily understood why contractual research continues to be an important part of ISRA's research portfolio; it offers concrete research opportunities for researchers and a relatively secure source of financial support for research programs.

The Matam case also poses several problems. Research questions raised by extension agencies arise from immediate problems and constraints and as a result are often very specific and localized. Consequently, they may not represent high priority questions for researchers. Moreover, by responding to contractual research opportunities, researchers face considerable pressure to draw fast, and perhaps premature conclusions and policy recommendations. Finally, contractual research by its nature cannot offer the long-term funding required to build a system that provides continued access to researchers by farmers or that encourages researchers to respond to farmer defined problems.

Consequently, we suggest that agencies such as ISRA should not engage in contractual research as currently defined. The extension agencies should have the technical capability to undertake pre-extension work directly with farmers and to evaluate research results that are directly relevant to the objectives of the agency's production program.

The ISRA-SOMIVAC Liaison Unit does offer one means to build a long-term relationship that serves both researchers and extension personnel and through which farmers can influence research and extension programs. Its activities can be defined to resolve specific problems and to seek the longer-term development of improved technology.

A Liaison Unit does not, however, substitute for direct collaboration between researchers and farmers or for measures to increase farmer influence in agricultural research and policy. At best, a Liaison Unit can encourage such collaboration by providing a framework supportive of on-farm research and by reducing the incentives to pursue bureaucratically driven or more academic research interests and concerns. The ISRA-SOMIVAC Liaison unit has not yet institutionalized a farmer driven incentive system for research and extension programming. This will require a long-term and deliberate effort. Unless this effort is made, the researchers, state agencies, and donors--not farmers--will continue to be the most important vested interest groups in Senegal's agricultural research and development.

The Contribution of PSR to R-E in Senegal

The ISRA Production Systems Research Department is only three years old, but with significant financial and technical assistance it has been able to launch three PSR Teams in three regions of Senegal since 1982. The

Department's research staff is composed principally of young, recently trained Senegalese researchers; as a result, experienced expatriate scientists will be needed to advise these young researchers and to continue programs while awaiting those currently in overseas training. While the PSR Department is relatively young, we can suggest some areas where PSR contributes to research programming, and especially to improving the R-E relationship.

The PSR Department's mandate stipulates that farm level problems and constraints as defined by farmers are the PSR Teams' point of departure for research programming. In other words, farmers are more than PSR clients, they are full partners in problem identification and technology testing. The mandate also includes the reorientation of on-station programs to make them more responsive to farmer problems.

Several on-station programs at Djibelor are being strengthened because of researchers' efforts to respond to questions and problems posed by the PSR Team. Furthermore, researcher meetings and discussions at the Center suggest that the PSR Team has renewed a spirit of research relevance and an openness to new ideas and approaches among Center researchers. On-station researchers respect the importance of PSR testing of their results while the PSR Team, in turn, understands the significance of maintaining solid on-station programs to assure the provision of testable technology.

The response of extension agencies and government officials to the consequences of the PSR mandate is unclear. Given the profound and continuing nature of Africa's agrarian crisis, many governments are beginning to revise their agricultural development policies.[16] In Senegal, the recently announced New Agricultural Policy calls for a dramatic reorganization of agricultural extension and proposes several measures to encourage more private initiative in Senegal's agricultural sector. Some parastatal extension agencies are being disbanded or drastically reduced in favor of giving cooperatives and producers' groups more responsibility for input supply and marketing.[17]

The sense of urgency among policymakers to resolve the agrarian crisis creates demands on researchers for quick-fix solutions. At the same time, given their appreciation of the complex nature of the agrarian crisis, government policymakers are receptive to the innovative programs of ISRA's PSR Teams. Ultimately, the preeminent challenge to the PSR Department is to capture this opportunity and create a research structure with its cornerstone the assurance of farmer access to new technology and an influential voice in agricultural research and development programs.

Footnotes

[1] See Senegal, Ministere du Developpement Rural, Direction des Services Agricoles, Actes des Journees d'Etudes sur la Recherche et la Vulgarisation, Rufisque, Senegal, Secretariat d'Etat a la Recherche Scientifique et Technique, Les Liaisons Recherche-Developpement, Propositions Pour Une Organisation. P. Viguier et R. Tourte, Ministere de la Cooperation de la Republique Francaise, Octobre 1979.

[2] See SAED - Bilan et Perspectives, May 1983; Study paper prepared by the World Bank Group, the French Ministry of Foreign Affairs, Cooperation and Development, the Central Fund for Economic Cooperation (CCCE) and the U.S. Agency for International Development/Senegal. This document calls for the "better use of research results and a reorientation of the research-development relationship." Also see the Agricultural Research and Planning Project Paper (USAID/Senegal, April 1981) in which the disbursement of second year funding is conditional upon the approval of a protocol agreement between ISRA and SOMIVAC (the regional extension and development agency for the Casamance) "concerning research/extension linkages in conducting production systems research."

[3] These two programs are still in the planning stages.

[4] Agricultural research is not included in planning for primary sector development in Senegal's four-year Economic Development Plans. It is treated instead as part of a fourth sector which regroups several activities, including "Studies and Research." See Senegal, Ministere du Developpement Rural, Bilan Global des Realisations du Gouvernement en Faveur du Monde Rural Depuis l'Independance, Dakar, Fevrier 1982; Senegal, Ministere du Developpement Rural, La Nouvelle Politique Agricole, Dakar, Avril 1984.

[5] At a recent (October 1984) workshop entitled "An Orientation to Farming Systems Research," held under the auspices of the ISRA Production Systems Research Department, these charges and countercharges dominated the working group sessions which were devoted to a discussion of R-E linkages. (The workshop proceedings are in preparation).

[6] The history of agricltural research and research policy in Senegal needs to be written. The most complete summary can be found in Michel Benoit-Cattin (Editor) Recherche et Developpement au Senegal. (In preparation.)

[7] See Bilan Global des Realisations . . . , Annexe 12. Also see, Senegal, Ministere de l'Enseignement Superieur et de la Recherche Scientifique, Secretariat d'Etat a la Recherche Scientifique et Technique, Evolution des Surfaces Cultivees et des Productions dans l'Unite Experimentale de Thysse-Kaymor, de 1970 a 1980, par G. Pocthier, Premier Seminaire sur le Mais, 21-23 Janvier 1981, ISRA, CNRA de Bambey (Janvier 1981).

[8] The research-development aspect of an ARDI was basically similar to what is now called a "recommendation domain." See R. Billaz and M. Dufumier, "Les Unites Experimentales du Senegal" in Recherche et Developpement en Agriculture (Paris: PUF, 1981).

[9] See discussion in E.H. Gilbert, D.W. Norman, F.E. Winch, Farming Systems Research: A Critical Appraisal. MSU Rural Development Paper No. 6 (East Lansing: MSU, Department of Agricultural Economics, 1980).

[10] In Senegal, Regional Development Agencies (SRDR-Societe Regionale de Developpement Rural) are responsible for rural development within a fixed regional/agro-ecological zone. In addition to broad rural development objectives, the Government of Senegal assigns specific crop production objectives to these agencies. Those agencies with which the PSR Department have the most contact include: SAED, The Senegal River Development Agency; SODEVA, The Agricultural Development and Extension Agency (primary for the Groundnut Basin); SOMIVAC, the Casamance Development Agency and its affiliated agency, PIDAC, The Integrated Project for Agricultural Development in the Casamance.

[11] The Jardin de Richard (Richard-Toll) was established in 1824 to experiment with the irrigated production of cereals, fruits and vegetables. Unrealized plans for the first water control project along the Senegal River date from 1904.

From 1939 through 1953 most irrigated agricultural production activities in the valley centered around Richard-Toll and were managed by the Agriculture Service and the Mission de'Amenagement du Senegal. Following a series of financial management problems MAS activities were transferred to a public works company, ORTAL, which was replaced at independence by the Societe de Developpement Rizicole du Senegal (SDRS). In 1971, the Compagnie Sucriere Senegalaise (CSS) took over 7,000 ha for sugar cane production, leaving only the "Colonat du Richard-Toll" to continue to be managed as a state company (en regie).

SAED was created in 1965 in the wake of the failure of another regional agency, Organisation Autonome du Delta (OAD); in 1974 SAED also took over from the Organisation Autonome de la Vallee (OAV) and extended its zone of activities to Podor, Matam and Bakel.

[12] The Diama is a major anti-salt dam under construction near St-Louis. It will raise the water level upstream and assure fresh water for between season crops. The Manantali, which is located much further upstream, will create an 11 billion m^3 reservoir and in addition to its hydroelectric and naviagation potential will facilitate the irrigation of 240,000 ha in Senegal.

The Sahelian climate throughout the valley is characterized by one rainy season from the end of June until October. Before the recent series of drought years, the average rainfall varied from 400 mm/year in the Delta to 700 mm/year in the Upper Valley.

Complete water control is provided by SAED or by village pumps, and three agricultural seasons can be distinguished: a rainy season (June-October) during which rice cultivation dominates; a cold, dry season from November to February which is ideal for many vegetables, and a hot, dry season from March to June.

In November 1984, Senegal hosted a major international conference under the auspices of the Senegal Valley Development Authority (OMVS) to elaborate an "apres-barrage" strategy.

[13] The Lower Casamance in southern Senegal covers an area of approximately 7,300 km^2, which corresponds to the estuary of the Casamance River. The area is quite flat and includes an extensive network of mangrove swamps; saltwater commonly intrudes 200 km upstream. Rice production is traditional throughout the low-lying inundated areas, but with the declining rainfall in recent years, rainfed upland cereals and groundnuts have become more important crops. The population of the area is estimated at 260,000, of which the Diola is the largest ethnic group. Senegal's development plans commonly refer to the Casamance as Senegal's future bread basket, yet since 1968 the area has experienced cereal deficits. See Jolly, et al. (1985) and Posner, et al. (1985). Since 1978, USAID has financed the Lower Casamance Integrated Rural Development Project (PIDAC) under the auspices of the Agency for the Development of the Casamance (SOMIVAC). The Djibelor Agricultural Research Center is one of ISRA's oldest centers and it is currently staffed by approximately 20 researchers, of which almost one-half are affiliated with the PSR Department.

[14] The first ISRA-SOMIVAC R-E Unit was established in 1977 to foster greater research-extension collaboration. It had essentially a life on paper until March 1980 when it convened to review SOMIVAC's activities and concerns, and ISRA's research programs. This meeting did not lead to any joint activities or programs.

As noted above, the signing of the protocol agreement was a condition imposed by USAID/Senegal to the second disbursement of funds under the Senegal Agricultural Research and Planning Project.

[15] Following the PSR Team's "discovery" of the importance of rainfed, upland crops in the Lower Casamance, the Team was instrumental in opening up a 40 ha area near the Djibelor Center, primarily to provide on-station researchers with the means to run trials on rainfed crops.

[16] See Carl K. Eicher (1982) "Facing Up to Africa's Food Crisis." Foreign Affairs 61:151-174; Carl K. Eicher (1983) "West Africa's Agrarian Crisis." A paper presented for the Fifth Bi-Annual Conference of the West African Association of Agricultural Economics, Abidjan, Ivory Coast, December 7-11, 1983. Also see Michael F. Lofchie (1975). "Political and Economic Origins of African Hunger." Journal of Modern African Studies 13:551-567.

[17] In keeping with government policy, SODEVA recently released 708 of its 1,258 employees, of which 160 were government civil servants who are now awaiting assignment by the government civil service commission; 37 were hired by a major oilseeds and processing firm, SONACOS; 511 have no guaranteed employment.

Commonly Used Abbreviations

French Research Institutes (Selected)

CIRAD	(Formerly GERDAT): Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement
CTFT	Centre Technique Forestier Tropical
IEMVT	Institut d'Elevage et de Medecine Veterinaire des Pays Tropicaux
IRAT	Institut de Recherches Agronomiques Tropicales et des Cultures Vivrieres
IRTC	Institut de Recherchers du Coton et des Textiles Exotiques
IRFA	Institut de Recherches sur les Fruits et Agrumes
IRHO	Institut de Recherches pour les Huiles et Oleagineux
ORSTOM	Office de la Recherche Scientifique et Technique d'Outre Mer

Senegal Regional Development Agencies (Selected)

SAED	Societe Nationale d'Amenagement et d'Exploitation des Terres du Delta du Fleuve Senegal et des Vallees du Fleuve Senegal et de la Faleme
SODEFITEX	Societe pour le Developpement des Fibres Textiles
SODEVA	Societe de Developpement et de Vulgarisation Agricole
SOMIVAC	Societe pour la Mise en Valeur de la Casamance
PIDAC	Project Integre pour le Developpement Agricole de la Casamance

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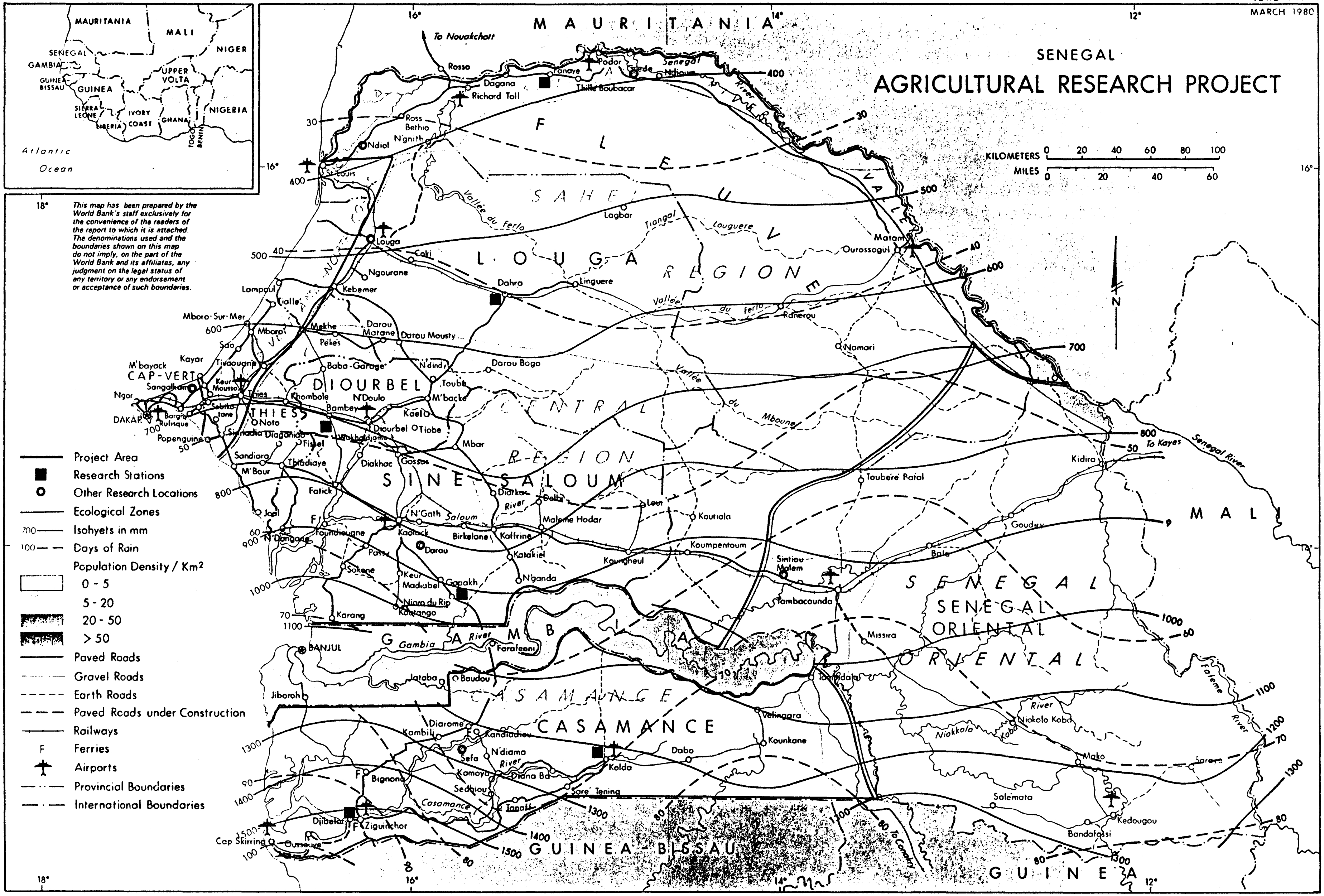
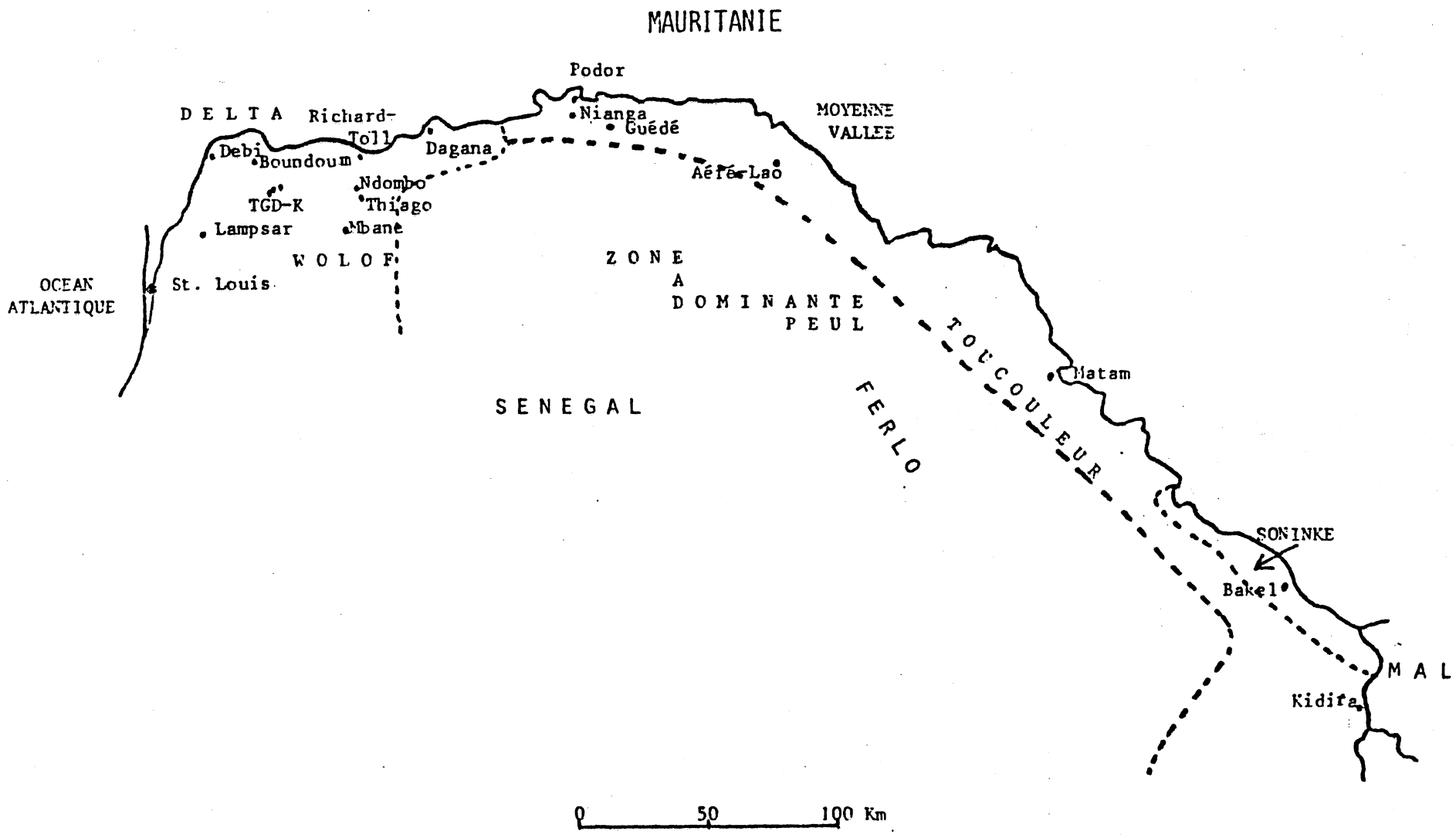
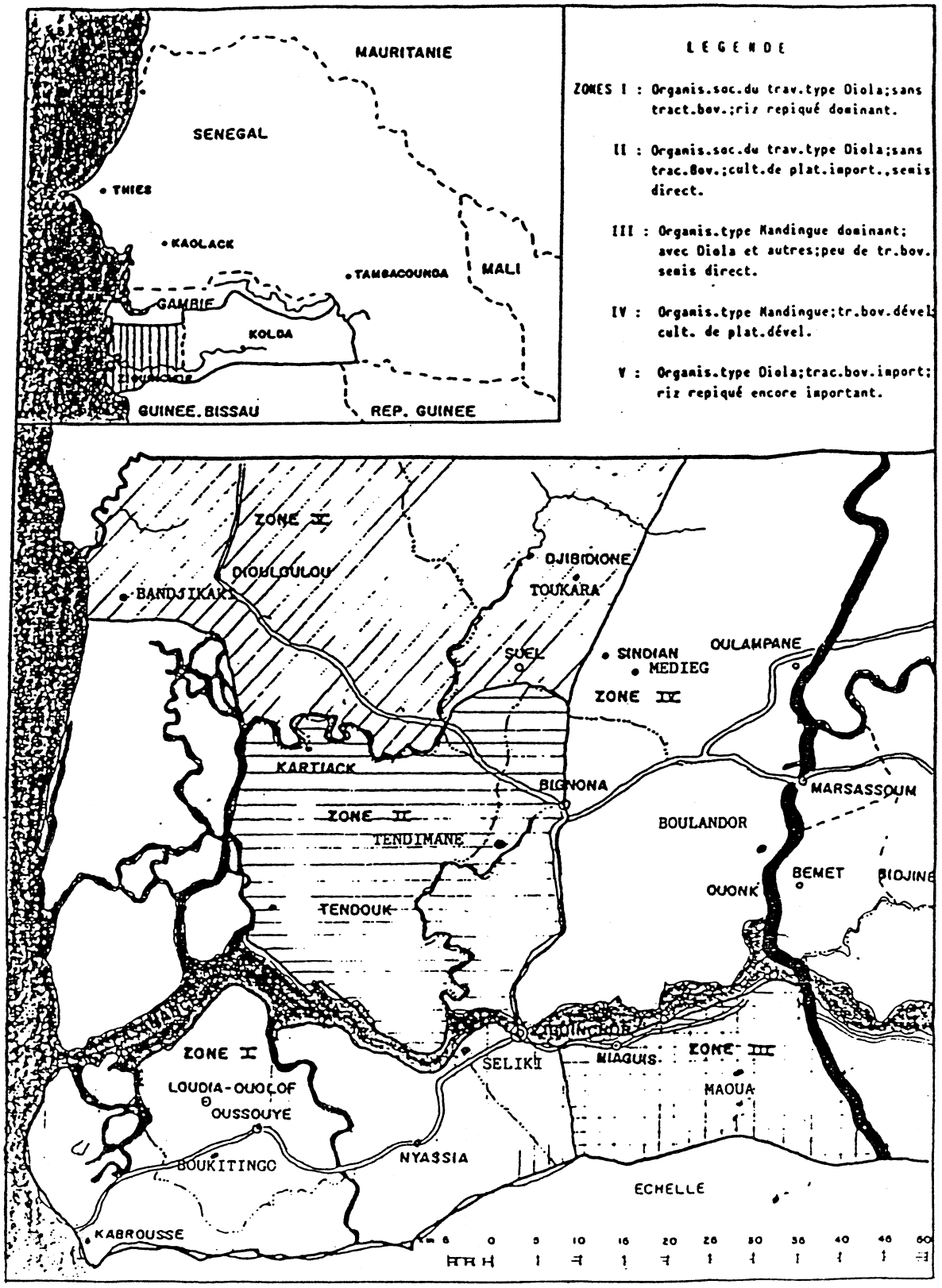


Map 1. Location of Agricultural Research Facilities in Senegal.



Map 2. The SAED Zone of Intervention



Map 3. The Agricultural Zones of the Lower Casamance

(Source: CRA-Djibélor, Equipe Systèmes)

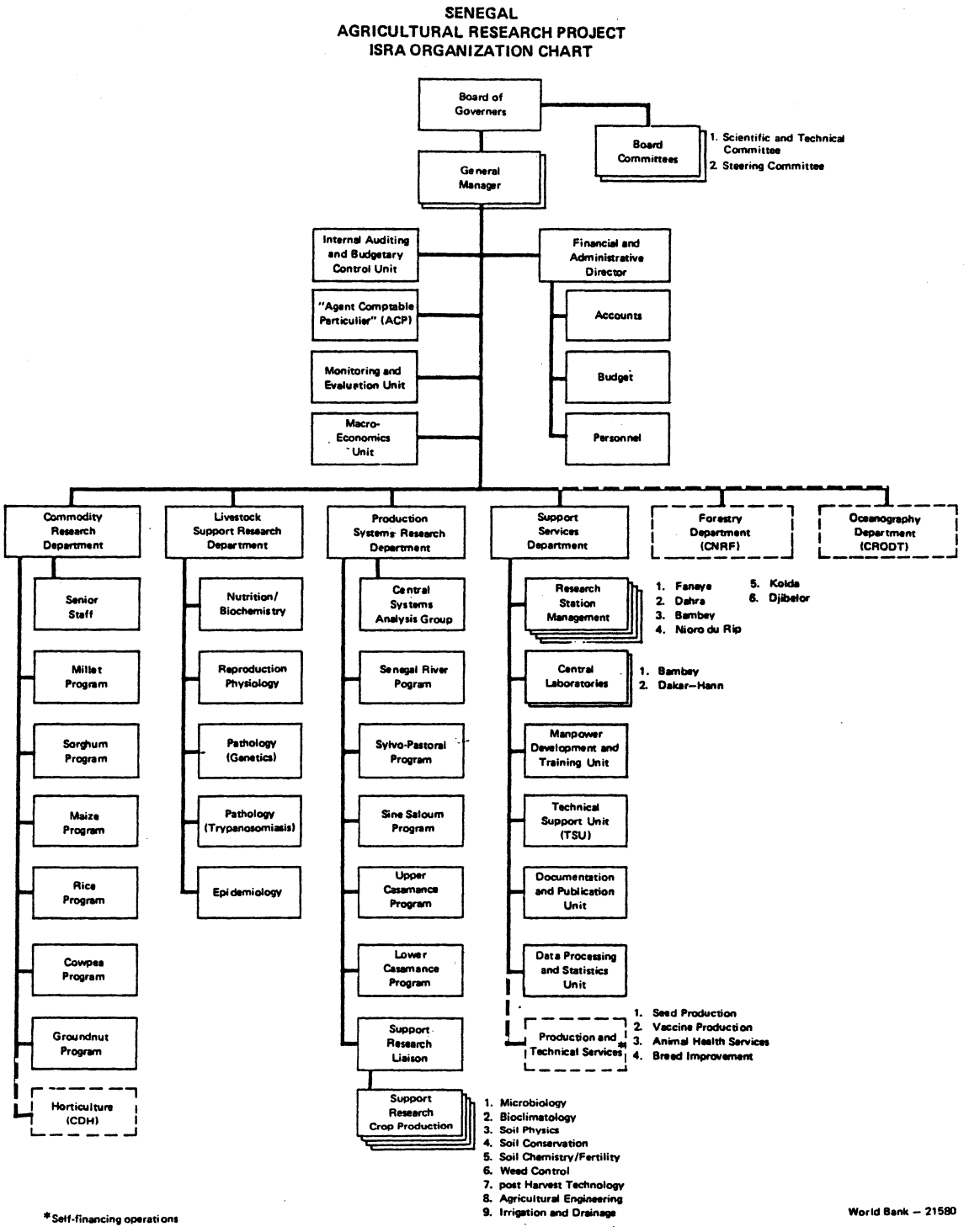


Figure 1. Senegal Agricultural Research Institute Organization Chart.

THE EVOLUTION OF FARMING SYSTEMS RESEARCH AT THE NATIONAL INSTITUTE OF AGRICULTURAL RESEARCH OF NIGER

Samba Ly, Gilbert Numa, Moussa Goube,
Chandra Reddy, Robert Deuson, Scott Swinton

INTRODUCTION

Niger is a country of 1,267,000 km^2 situated in the heart of West Africa. It is bordered on the east by Chad, on the west by Mali and Burkina Faso, on the north by Algeria and Libya, and on the south by Nigeria. Besides being very large, Niger is a desert country (approximately four-fifths of its area being covered by the Sahara). Climatic variability among other factors exerts a strong influence over the country's economic and social development.

Agriculture, which employs 80% of the population of six million, is limited by fickle rainfall and high temperatures. The rainy season lasts only four months, from June to September. Average temperatures from 27° to 29°C are typical, with maxima in May-June and September-October.

Given such conditions, people practice manual, extensive agriculture centered around millet, sorghum, and cowpea, which are often grown in association (Reddy and Gonda, 1985; Swinton, Numa, and Ly, 1985).

Chronic droughts and soil deterioration have broken the cropping cycle and undermined traditional practices. Deterioration was partly the result of monocropped export crops and of demographic growth that was accompanied by an expansion of land under cultivation and the subdivision of fields, with a corollary disappearance of fallows.

In order to meet expanded demand, particularly for cereals, Nigerien agriculture needs to move towards an evolved intensive system of crops and livestock, and one that relies more on a base provided by agricultural research.

AN INTRODUCTION TO INRAN

History of the Creation of INRAN

Since the recent years of drought, the Nigerien countryside has encountered numerous and complex problems. Aware that agriculture and livestock raising, the pillars of economic development in Niger, cannot progress without the solid support of agricultural research, the government decided in January 1975 to create the Institut National de Recherches Agronomiques du Niger (INRAN). INRAN pulled together and took over the various French research organizations which had hitherto been responsible for carrying out agricultural research.

Research Directions at INRAN

Niger's national policy of food self-sufficiency determines the nature of agricultural research at INRAN. Orientation is toward subsistence crops (millet, sorghum, cowpea, and groundnut), with emphasis being placed on varietal improvements and cultural practices. In contrast with the former approach, the strategy is primarily directed toward applied research taking account of environmental conditions and the real needs of the rural world. To carry this out, INRAN is divided into five technical departments responsible for research in the following areas: agronomy, ecology, animal and veterinary sciences, forestry, and economics.

Research Infrastructure

In operating its numerous research programs, INRAN utilizes 58 university educated researchers, including 25 Nigerians. Most research is carried out on the two principal research stations (Tarna and Kolo), which cover a total of 380 ha. These stations are supported by a nationwide network of substations and research support sites. During the 1983-84 fiscal year, the budget totaled 633,330,000 C.F.A. francs (U.S. $1,583,325 at an exchange rate of 400 FCFA per dollar). Of this sum, about 16% went into the financing of non-salary research activities (INRAN, 1984).

FROM RESEARCH TO EXTENSION

The Traditional Approach

On-Station Research and the "Extension Recommendations Themes." In the past, agricultural researchers would synthesize research station results into cropping practices "recipes" for the agricultural extension service. These were called "extension recommendations themes" (INRAN, 1982). The research approach was thoroughly specialized and particularistic.

The results coming off the research stations and substations were only rarely checked in the peasant farming environment, and the differences between the two were at times striking. Recommended practices tended to focus almost exclusively upon technical or technological aspects of farmers' problems, without taking into account the structures and systems of production and paying insufficient attention to socioeconomic repercussions on the lives of rural people. As a result, extended practices were rarely adopted by small farmers.

Agricultural Extension and the Multilocational Trials. Such a research approach did not facilitate the extension of the agricultural recommendations. Moreover, collaboration between researchers and extensionists was limited to contacts at the annual meetings. Indeed, from 1979 to 1984, INRAN was part of the Ministry of Higher Education and Research, while the extension services were located in the Ministry of Rural Development. (The two are now joined within the latter Ministry).

Toward the end of the 1970s, an initial effort was begun to link research and extension. At the suggestion of the extension agency, INRAN undertook a program of multilocational trials which are carried out by extension agents under experimental designs provided by INRAN. They are placed across the country at extension sites. For the first time recognizing officially the need to distinguish among different agricultural zones, INRAN divided the multilocational trials between a low-rainfall zone (annual mean under 400 mm) and a moderate rainfal zone (over 400 mm). For the varietal trials, a second distinction was made between dune (sandy) and valley (sandy-clay) soils.

The goal of the multilocational trials is to evaluate varieties and fertilizer levels before extending them. Results of these trials have been very uneven during the initial years. These variations were due not only to differences inherent to the physical environment, but also to a shortage of adequate supervision of the trials. Since 1970, the rural development projects have contributed to the improvement of the management of these trials. Since 1984, INRAN has simplified the experimental designs of the varietal trials entrusted to the extension service, leaving the more complex designs on the interaction of varieties with fertility levels to the applied research sections of the rural development projects.

The Development of the Farming Systems Approach at INRAN

After the creation of INRAN and the reorientation of research toward development needs, it rapidly became apparent that agricultural research should be placed in its true context and should take account of rural realities. There have been several attempts to do this, beginning in 1977. From 1977 to 1983, the approach pursued was to carry out case studies on agricultural recommendations already being extended to farmers. There were three different versions of this approach.

Monitoring the "Test Farmer" at Tarna. At first, an artificial farm was established on an existing research station in order to study the application of the agricultural recommendations package under the best possible conditions and to evaluate their profitability. From 1977 to 1983, the monitoring of the "test farmer" (*paysan pilote*) at Tarna allowed a better understanding of how the extended agricultural recommendations performed in an environment with unconstrained access to capital (chiefly in the form of fertilizers, improved seed varieties, and animal traction equipment) (Roesch, 1982). Overall, the study showed that the recommendations package could provide attractive returns, but the profitability of individual recommended practices and the returns to capital investments were never evaluated.

Monitoring Two Graduates of the Farmer Training Centers. A second attempt at evaluating the extended agricultural recommendations studied the behavior of two farmers trained at the farmer training centers (*Centres de Promotion Rural*) of the Maradi Rural Development Project (Roesch, 1982b). The objectives of this study were "to test the validity of the techniques taught, the fashion in which these techniques were adapted in the field, the problems and deficiencies in the training, and the social and economic

constraints which an ex-trainee was likely to encounter . . . . For INRAN, interest focused on the study and improvement of cultural techniques and the identification of peasant needs in agricultural research." (Roesch, 1982a).

To carry out the study, two training graduates were chosen, one from a village on dune soils and the other from a village on sandy-clay soils. The study took place from 1979 to 1981 and was expanded in 1981 to cover 28 farms located near the two farms that were being studied in depth.

Monitoring the farms of the two training center graduates from the Maradi Project and the survey of the 28 farms surrounding them allowed feedback not only to the extension service, but also to INRAN (Roesch, 1982a). It indicated that certain hitherto neglected areas of research should be considered, notably the feeding and training of draft animals, making the agricultural recommendations more flexible in the face of climatic and economic uncertainties, intercropping, managing organic matter, and addressing the high cost of the equipment needed to practice the recommended techniques.

The "Experimental Agricultural Production Units" Operation. The third approach adopted for the evaluation of the agricultural recommendations, which continues to this day, aims at studying the recommendations on sample farms managed by peasants who have received no previous training. These farms have been named "Experimental Agricultural Production Units" (*Unites de Production Agricole Experimentales*) or UPAE. The objectives of the UPAE study are: 1) the identification of real constraints encountered in the application of the recommendations, and 2) the search for solutions that will relax or remove the observed constraints through combining all factors of production, including socioeconomic parameters which have long been neglected (DECOR, 1983a).

This program has evolved through several stages since its beginning in 1980. A survey of 113 farms in Filingue Arrondissement made it possible to choose six for an indepth study. Six farms are split between two Zarma villages, one located on dune soils and the other in a large dry valley. After one year of monitoring the farms without any researcher intervention, INRAN began in 1982 to introduce certain recommendations on a part of each UPAE. The recommendations include:

1) monocropped millet and cowpea,

2) improved varieties of millet and cowpea,

3) destumping,

4) higher planting density (millet at 10,000 hills ha^{-1}; cowpea at 55,000 plants ha^{-1},

5) mineral fertilizers (urea and superhosphate, 100 kg ha^{-1} each),

6) pest management, and

7) poultry farming with improved species.

In 1984, the sample was expanded to include five UPAE in each of the two villages, as well as 15 farms (without researcher intervention at first) in a third village on dune soils but made up of ethnic Hausas.

Farmer reactions to the introduction of these recommendations have provided lessons to researchers (DECOR, 1984):

1) Use of the line tracer (to guarantee recommended planting density) is difficult;

2) Mixing urea into the soil around each hill of cereal crops considerably increases labor time required;

3) A millet variety which tillers better than the recommended one (HKP) should be developed;

4) A cowpea variety that tastes better than the recommended variety (TN 88-63) should be developed.

The UPAE program is allowing the identification of both favorable and constraining factors affecting peasant adoption of agromonic practices developed on the research station and recommended to the extension service. Moreover, the results of this program have emphasized the importance of elaborating on-station research programs based *a priori* on farmers' objectives and the actual constraints imposed by their environment.

The Conception and Birth of the Current Approach. The results of the three programs aimed at evaluating the application of the agricultural recommendations confirmed a previous belief by agencies involved in extension and rural development that on-station research and agricultural extension both need a reorientation. The monitoring of the two farmer training center graduates from the Maradi Project in particular focused on the lack of recommendations for intercropping and the homogeneity of recommendations that does not take into account the variety of farmers' ecological and economic conditions. Recommendations requiring greater investments than farmers can afford are particularly unlikely to succeed. The UPAE operations further established the importance of developing recommendations which meet the specific needs of farmers in different agroclimatic zones of the country.

These discoveries have led INRAN to reflect upon how to assure that the products of agronomic research will better meet the needs of its clientele. It is clearly inadequate simply to evaluate agricultural recommendations after they have already gone into extension or to conduct multilocational trials managed by extension agents to assure the appropriateness of these recomendations. If we accept that the peasant farmer is the final user of our research products, then a profound reorientation of our scientific approach is necessary. It becomes imperative to understand their objectives, needs, resources, and the constraints they face before

elaborating research programs. From the outset, they must be invited to join INRAN researchers in formulating research objectives.

THE "FARMING SYSTEMS RESEARCH" WORKING GROUP

In 1984, INRAN established several technical groups called "working groups," among which was the working group on "Farming Systems Research." The group's objectives are as follows:

1) To establish with INRAN a multidisciplinary team composed of researchers from different fields (biologists and economists) and extension agents (developers).

2) To formulate research programs on farming systems and, after their execution by the multidisciplinary team, to evaluate the results and generate feedback for future programs.

3) To inform INRAN administrators of the progress achieved in these programs and to ensure administrative support for them.

This working group, which is coordinated by the head of the Rural Economics Department assisted by two biological and two economic researchers, counts among its members production agronomists, plant breeders, entomologists, plant pathologists, veterinarians, soil scientists, agricultural chemists, agricultural economists, and extension agents.

So far, the working group has accomplished the following tasks:

1) formation of a multidisciplinary team,

2) organization of a rapid reconnaissance survey (*sondeo*), and

3) elaboration of an on-farm trial program.

CURRENT RESEARCH ON FARMING SYSTEMS AT INRAN

At present, INRAN has adopted a multidisciplinary approach oriented toward satisfying the specific needs of farmers from different agriclimatic zones of Niger. The development of this approach englobes the following steps:

1) the establishment of multidisciplinary teams,

2) a rapid reconnaissance survey (*sondeo*),

3) on-station agronomic research,

4) an indepth socioeconomic survey, and

5) on-farm agronomic trials.

The Multidisciplinary Reconnaissance Survey (*sondeo*)

As one of its annual field visits for other INRAN researchers, the Rural Economics Department organized a trip for the multidisciplinary team to the Experimental Agricultural Production Units at Tashi, Legare, and Kouka in Filingue Arrondissement. The team, made up of three soil scientists, a production agronomist, three economists, plant breeder, and statistician, evaluated the work underway in order to see what contribution the other INRAN research departments could make to these programs. In this particular case, the principal difference vis-a-vis the approach followed by Hildebrand (1979) in Guatemala was that the rapid reconnaissance survey verified a program already underway rather than an area where research had not yet begun.

Upon arriving at the villages, the team found that after three years of on-farm demonstrations, farmers on the UPAE still limited the application of the agricultural recommendations to the INRAN test fields. When asked, "Why don't you apply the recommended techniques to your other fields?," they gave two principal reasons. First, they do not like monocropping, believing that it does not make rational use of space and that it increases the danger of a poor harvest when rains are poor. Second, agricultural inputs (chiefly mineral fertilizers) were unavailable to farmers, as much for financial reasons as because they were logistically difficult to obtain (the farmer had to travel 17 km by donkey). They found the recommended application technique for urea fertilizer (localized around the hill of millet) to be too time-consuming, since it coincides with the weeding period. As farmers saw it, if fertilizer is not available, it is unwise to plant at the high density recommended by INRAN (10,000 hills of millet ha^{-1}).

Important lessons for on-station research came out of the multidisciplinary reconnaissance survey. Farmers' unwillingness to practice monocropping once again convinced researchers of the importance of developing intercropping recommendations. The unacceptability of the recommendations package as a whole suggested a need either to simplify the recommendations or introduce them in stages while adapting them to local conditions in the target zones. These lessons have brought three changes to INRAN: the renewal of research on intercropping, on-farm verification of techniques developed on the research station before extension to farmers, and the acceptance not only by researchers but also by administrators of the importance of multidisciplinary approach in on-farm research programs. The participation of administrators (the heads of three research departments) in the team's activities facilitated the rapid adoption of these new directions.

On-Station Agronomic Research

In order to resolve some of the problems mentioned above, the General Agronomy Section undertook a cropping systems research program at Tarna and on the different INRAN research substations early in 1984. The program is in two parts: 1) research on cultural practices that can be adopted immediately by the farmers, and (2) long-term research aimed at reaching a better understanding of intercropping systems and their interaction with

ecological factors (e.g., rainfall) and factors influencing farmer access to production resources (such as animal traction equipment and fertilizers). Under the first part of the research program, trials on varieties, planting density and geometry, and land preparation techniques were initiated in 1984 at Tarna at the substations and continued in 1985. The same is true for the second part of the research program, which encompasses experiments on plant physiology, water utilization, insolation, plant nutrients, insect incidence, plant diseases, weeds, and crop rotations.

Aside from the agronomic experimentation, results from socioeconomic surveys carried out by the Rural Economics Department, as well as contacts with other researchers and extensionists, are utilized to identify the objectives, resources, and constraints faced by farmers who are the targets of on-station research.

The on-station research aimed at finding technical solutions to production problems is conducted by the General Agronomy Section with the collaboration of researchers from other departments. The on-farm trials were initiated on a small scale by the Rural Economics Department in 1984 in order to learn to manage the logistics of such trials. They have been continued in 1985 in conjunction with the General Agronomy Section. These trials are based on research results for on-station experimentation in 1984 at Tarna and on the substations. Eventually, these on-farm trials will lead to definitive recommendations that will be transmitted to rural people on a large scale by the agricultural extension service.

On-Farm Research

On-farm research is carried out in order to study farmers' needs and to evaluate techniques and new varieties that have performed well in a controlled environment. The focus is on surveying farmers' needs and orienting agronomic research in order best to meet those needs.

The identification of farmers' needs is done in two stages. The first, already described, is the multidisciplinary rapid reconnaissance survey. This permits a general assessment of needs as felt by farmers and observed by researchers in the course of a single visit. In order to acquire a more complete understanding of farmers' needs and to be able to prioritize these different needs, it is necessary to monitor closely the management of their farms.

Socioeconomic Research

Objectives. In order to monitor farm management, a socioeconomic survey is carried out with the following objectives:

In the short run:

1. To establish a typology of farms in order to group farms together by recommendations domain.

2. To identify farmers' objectives.

3. To identify the constraints and the factors that favor the realization of these objectives.

In the medium run:

1. To help establish priorities for agronomic research given farmer constraints and the likelihood that research can find solutions for them.

2. To help guide national agricultural policy in order to relax economic constraints (for example, by improving access to modern inputs and by bringing product prices into equilibrium).

3. To evaluate the results of agronomic and economic research.

Methodology. A research program in a given zone of the country begins with the collection of baseline data on the region. This data collection can be done either through library research or failing that, by a survey of the entire zone. For two programs, a lack of information forced INRAN to undertake baseline surveys. In both cases, a large sample of farmers was drawn at random for an entire arrondissement (113 farms in Filingue in 1980; 348 farms in Madarounfa in 1982). The analysis of data collected during the baseline survey furnished the necessary information to establish recommendations domains. In the case of the study on the interaction between rainfed and irrigated agriculture along the River Niger, the baseline information necessary was already available from the National Office of Agricultural Water Management (ONAHA).

The second stage is an indepth survey of a subsample of villages intentionally chosen to represent each recommendations domain. At this stage, peasant objectives are studied, as well as farm resources and agricultural activities. The goal of these studies is to be able to:

1. quantify the agricultural resources of typical farms,

2. establish partial budgets for different cropping systems and technology levels, and

3. integrate these into a model of a typical farm operation.

Results. The initial results of the socioeconomic surveys have made it possible to establish recommendations domains and thus to choose sample villages for indepth studies. Each study zone represents a distinct region, particularly as regards rainfall, the principal constraint to agricultural production in Niger. As shown in Table 1, the northwest and center-south agricultural zones were chosen for their significant differences in rainfall, and the irrigation perimeters along the River Niger for their reliable supply of water on irrigated fields. Within each zone, the baseline information made it possible to choose villages having different characteristics of topography, soil texture, and predominant ethnic group (this last being linked to important differences in agricultural techniques).

The second analytical stage is to describe quantitatively the farms' agricultural resources and the utilization of these resources in different farming systems. It is not surprising to see in Table 2 that there exist quite substantial differences in farm resources according to the recommendations domain. For example, in the northwest of the rainfed agricultural zone, farms in the valley are smaller than those on the plateau. Resource utilization also varies by zone; consequently, so do cropping systems. Sorghum, for example, is present in all major cropping systems in the center-south of the agricultural zone of Niger (Madarounfa) while it is rarely encountered in the northwest (Filingue, except for the valleys).

Analyzing the data on labor time and the management of different cropping systems will allow the establishment of partial budgets by level of technology (animal traction and manual farming) and the cropping system. The utilization of farm resource information and the partial budget results within an input-output mathematical model will permit the identification of the principal constraints to agricultural production for each type of farm and the classification according to the value of marginal product which could be obtained as each constraint is removed.

Feedback. The creation of input-output mathematical models offers several important possibilities to agronomic researchers, as well as economists. Besides quantifying constraints, these models make it possible to simulate the impact of a new technology already tested on the research station when such a technology is introduced into an existing farming system on a typical farm.

The possibility of evaluating the farm-level profitability of an investment in the development of a new technology allows a more efficient management of agricultural research. The choice of a profitable technology increases the probability that it will be accepted by the farmer in the course of on-farm trials.

Obviously, a mathematical model is not something fixed and immutable. It lends itself to constant modifications and corrections so that it better approaches reality. For example, although at present INRAN's FSR program pays little attention to livestock production, this does not prevent it from being incorporated into farm models in the future.

The feedback between socioeconomic and agronomic research does not stop there. Agronomic research offers the possibility to verify the interpretation of economic research results. For example, in 1984 intercropping trials were installed in the three representative villages of Madarounfa Arrondissement to verify the hypothesis that agronomic conditions (chiefly soil texture) vary significantly from one recommendations domain to another. Although the drought prevented the crops from reaching maturity, the results of soil tests showed that soils in two of the villages were not different, which led us to assume that the differences in cropping systems between the two domains were due to the use of different agricultural techniques.

Eventually, feedback between research and the reality of the peasant world (via agricultural extension as well as on-farm trials) should play a primary role. Only lessons learned in the field can give a true evaluation of research results and the efficacity of communication between extension agents and farmers. We are still in the process of perfecting recommended technologies according to the needs of farmers in different zones of the country. At the current stage, the role of extension is limited to fixing research directions and evaluating the on-farm trials. Once certain recommendations have been transmitted to the extension service, its role in helping to evaluate the recommendations on a large scale will expand enormously.

On-Farm Trials

Objectives. The objectives of the on-farm trials are as follows:

1) To determine whether technologies proposed by on-station research are ready for extension.

2) To determine whether the proposed technologies should be re-evaluated by on-station researchers in order to take into account biologic and economic constraints encountered at the farm level.

3) To determine to what extent the extension and input supply services should prepare for the diffusion of these new technologies.

Types of On-Farm Trials. Two types of on-farm trials are distinguished at INRAN: 1) researcher-managed trials, and 2) farmer-managed trials.

The first type is used for developing new technologies which take into account actual farming conditions. The trials are very similar to those carried out on-station since the researcher controls all the experimental variables. These trials differ from those done on-station in that they are conducted on farmers' fields, under ecological conditions more varied than those on the research station, and taking into account the reactions of the farmer.

The second type of trials, those under farmer management, is used to study how and why the farmer adopts a new technology, wholly, partially, or rejects it. In this method, the farmer tries to adopt and adapt the new technology proposed within the context of the biological and socioeconomic environment.

Trials Adapted to Local Conditions. Farmer-managed trials frequently have coefficients of variation from 30 to 50%, thus considerably higher than those generally registered in on-station trials (Shaner, et al., 1982).

In order to reduce or eliminate these variations, on-farm trials at INRAN are conducted on relatively large parcels (1000 m^2), with sufficient repetitions (25 per zone), and are designed according to local conditions. Experimental blocks must be chosen according to predominant agroclimatic conditions in the region, and treatments must be adapted to the region. For

example, since rainfall is the determining factor in Niger, a single variety of millet cannot be recommended for several regions having different levels of rainfall. Hence, an early variety (HKP) was used for trials in low rainfall regions (mean of 300-450 mm year^{-1}) and another variety (CIVT) for higher rainfall regions (mean of 450-600 mm year^{-1}).

Given the high variability of rainfall and soils in Niger, INRAN's 1985 on-farm trials were divided among three distinct agroclimatic zones (Filingue, Madarounfa, and Kolo). These zones were chosen based on the recommendations domains previously defined. In addition, ICRISAT installed the INRAN on-farm trial experimental design in one of its village research sites.

Analysis of On-Farm Trials. INRAN's analytical methods are essentially centered around the desire to integrate the different disciplinary understandings of the rural environment brought by the team members.

First of all, agronomists determine the biological and technical feasibility of the recommendations proposed by finding out if there exist statistically significant differences between yields obtained using the proposed recommendations and those gotten using traditional practices. To do this, analysis of variance (ANOVA) is used. In contrast with on-station experimental analysis, the ANOVA can be done at higher levels of acceptable error (for example, 10% instead of 1 or 5%). In effect, the farmer may be willing to accept a higher risk of error than the researcher normally would (Perrin, et al., 1976).

Secondly, the economists establish the economic profitability of the proposed technology. Two methods can be used to do this: analysis of the entire farm, or the construction of partial budgets. The former method is appropriate for cases where the proposed new technology requires a profound transformation of traditional farming practices, either by demanding considerable capital investments or by strongly tipping the balance among existing production systems (the case of "heavyweight recommendations"). Whole-farm analysis requires a broad base of detailed information and sophisticated analytical tools (linear programming, for example). Since INRAN's on-farm trials so far involve only simple techniques, this form of analysis is not yet used.

The second method, the construction of partial budgets, is appropriate when the proposed recommendations represent a marginal change in traditional methods (the case of "lightweight recommendations"). Such a change necessitates neither fundamental reorganization of farm management nor great capital investment. Partial budgets make it possible to quantify the contribution of a recommendation to the farmer's net income. When several alternative recommendations are proposed, it is best to identify the one which will contribute the most to net revenue for its variable cost. Dominance analysis is used to do this. Such an analysis has been used at INRAN (Kennedy, et al., 1984).

CONCLUSIONS

At its birth in 1975, INRAN's role consisted of developing agricultural recommendations without thoroughly understanding the farming systems of Nigerien peasants. At that time, agronomic research, confined exclusively to the research station, was focused on monocropping and transmitted recommendations to the extension service in the form of recipes without having tested them under farmers' conditions. Having realized that certain recommendations were not accepted by Nigerien farmers, INRAN set up two new programs to evaluate the recommended techniques: 1) the multilocational trials, and 2) the monitoring and evaluation studies of farmers using the recommended techniques (the monitoring of the "Test Farmer" at Tarna, the two farmer training center graduates from the Maradi Project, and the Experimental Agricultural Production Units of Filingue). The multilocational trials chiefly aim to ensure that the cultural practices and new varieties developed on the two principal research stations behave well agronomically elsewhere. The socioeconomic studies of the use of the extended recommendations aimed to identify the factors which facilitated or impeded their adoption and to suggest means of relaxing the constraints.

The fact that certain recommendations hold inherent constraints to their adoption (excessive labor time, high cost) brought INRAN to opt for a new approach. From the outset, it seeks to discover the needs of Nigerien farmers and to develop agricultural recommendations applicable to zones with sufficiently homogenous characteristics. Currently, INRAN's Farming Systems Research Program is a multidisciplinary program with scientists in both the social and biological realms. Once identified for research, an intervention zone is rapidly surveyed by a multidisciplinary team to determine its agronomic possibilities and the needs of its farmers. Simultaneously, a socioeconomic survey is begun in order to thoroughly understand farming systems in the zone and to quantify their parameters. The findings of this survey are examined jointly with the agronomists. Based on the reconnaissance survey and the socioeconomic study, the odds for the adoption of a new technology are evaluated within the context of the traditional farming systems. All promising technologies are then tested in on-farm trials. At first, these trials are carried out under researcher management. Those which do well are then repeated under farmer management.

Several years will be necessary before this approach can yield extendable recommendations. It has already brought about certain promising new research directions. The focus on intercropping research will doubtless lead to the development of recommendations more acceptable to farmers. Economic research will prevent unprofitable recommendations from being extended. The participation of farmers and extension agents in agricultural research will permit other factors liable to be overlooked by researchers to be taken into account. These new directions ensure that the products of agricultural research will better respond to the needs of Niger's farmers.

Footnote

[1] For an example of the methodology used to determine a recommendations domain, see Swinton and Ly, 1984.

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* Available in English from the authors.

Table 1

Characteristics of the recomendations domains

Crop Zone	Mean rainfall 1971-84*	Topography	Soil Texture	Dominant Ethnic Group	Number of Farms
	mm				
Rainfed					
Northwest (Filingue)	340	valley	sandy	Zarma	5
		plateau	sandy	Zarma	5
		plateau	sandy	Haoussa	15
Center-south (Madarounfa)	420	plateau	sandy	Peulh	26
		valley	sandy-clay	Haoussa	26
		plateau	sandy	Haoussa	26
Irrigated					
River-north (Tillabery)	147	valley	sandy-clay	Zarma/Sonrai	20
		valley	sandy-clay	Soninkee	19
River-south (Kolo)	220	valley	sandy-clay	Zarma	20

* In order to obtain an adequate time series, the figures given come from the following sites: Filingue from Filingue, Madarounfa from Maradi, Tillabery from Tillabery, and Kolo from Niamey airport.

Table 2

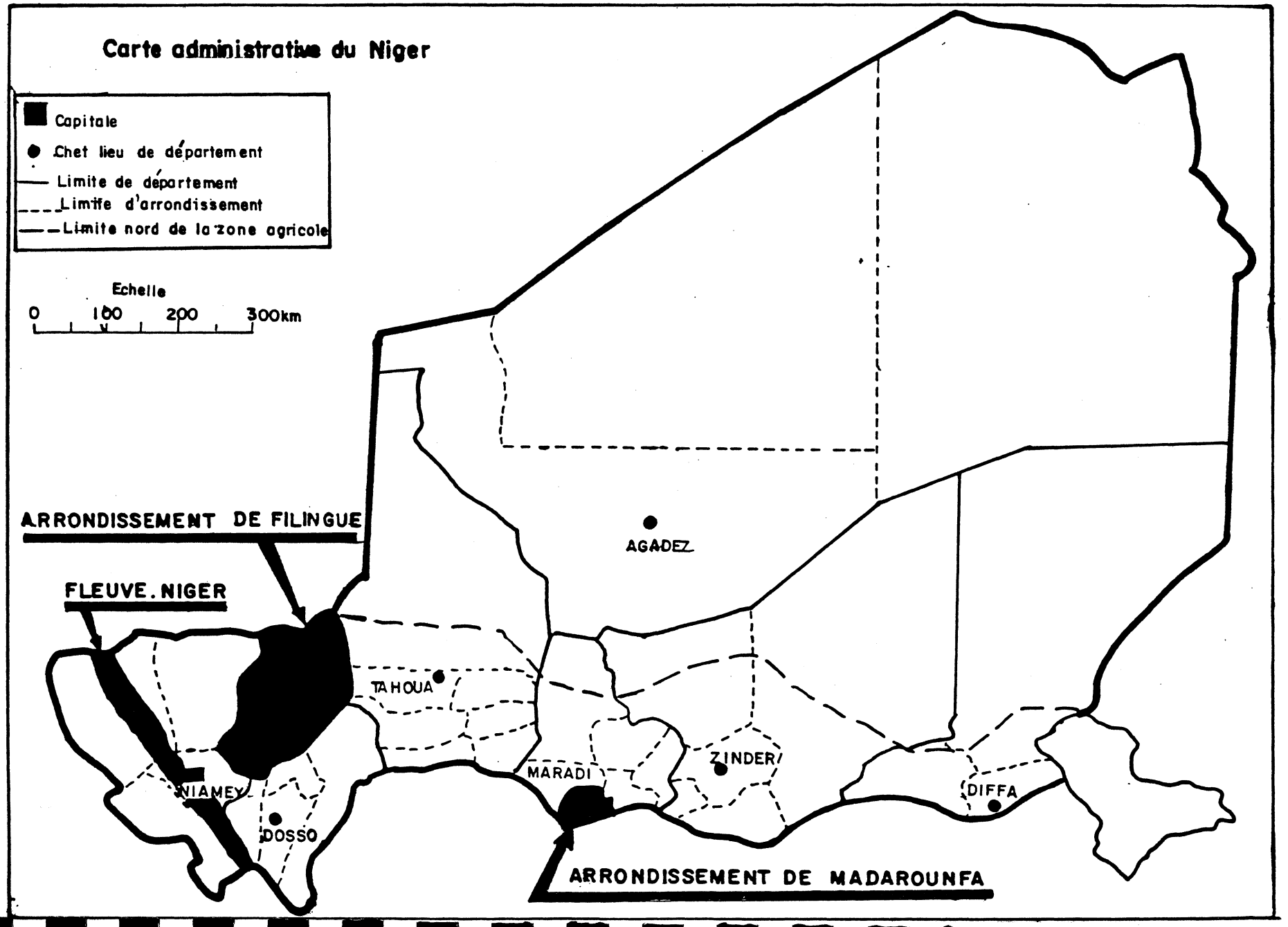
Salient characteristics of farms in 1984 by recomendations domain

Recommendation domains by crop zone	Mean farm size	Mean farm population	Livestock Bovine	Livestock Ovine/ caprine	Cropping system (*)
	ha	person	head		
Rainfed					
Northwest					
Valley - Zarma	6.7	8.6	1.5	2.8	MC,MSC,M**
Plateau - Zarma	15.8	10.8	0.5	2.7	M
Plateau - Haoussa	12.3	8.6	3.2	11.8	M,MC
Center-south					
Plateau - Peulh	4.1	5.5	3.2	5.6	MS,MSC
Valley - Haoussa	4.0	5.4	1.0	5.1	M,MSC,MS,MC
Plateau - Haoussa	8.5	9.0	1.8	14.6	MSC,MC,MS,M
Irrigated					
River-north					
Zarma/Songhai	3.9	4.4	5.2	1.4	MC,R
River-north					
Soinkee	1.5	3.7	1.9	0.8	MC,R
River-south					
Zarma	4.3	4.7	2.1	2.9	MC,R

Sources: Numa 1985, pp. 20, 35; DECOR 1983B, p. 138; Swinton 1985, pp. 6, 21, 24; Ly et Deuson 1985, pp. 22, 36, 40.

* Covering over 10% of the surveyed land area.
** By order of importance decreasing from left to right:
M = Millet S = Sorghum C = Cowpea R = Rice

GRAPHIQUE N°1 Position géographique des zones étudiées



A NEW MODEL FOR TECHNOLOGY TRANSFERENCE WITHIN FSR/E

Astolfo Fumagalli, Ramiro Ortiz, and Manlio Castillo

INTRODUCTION

Food production in Central America is mostly in the hands of limited resource farmers who comprise the largest proportion of farmers in those countries. Little has been accomplished for these farmers, not only in terms of generating technology appropriate to their needs and conditions, but also in promoting effectively its use. This fact is strongly influencing the economy of this region since 55% of the population are farmers and the productivity figures per farm and per hectare are low, and total food production is not meeting the needs of a population with a 3.1% annual growth rate, among the highest in the world.

Some of the governmental efforts in each of these countries towards the solution of the previously described problem have been expressed through the establishment of agricultural research programs with emphasis on food production. By 1973 in Guatemala, these efforts resulted in the creation of the Institute of Agricultural Science and Technology (ICTA). This national institution developed a model for agricultural research that focuses in on-farm activities, farmers' participation, and the collaborative effort of regional multidisciplinary teams (Fumagalli and Waugh, 1977; Ortiz, 1980; Gostyla and Whyte, 1980; Whyte, 1981). Through this new approach, ICTA has been able to generate and promote the use of technologies which are appropriate to the needs and resources of the farmers of the country. By the early 80s, this approach had been the key mechanism in an overall agricultural sector strategy that made Guatemala a self-sufficient country, and even exporter, of basic grains (Castillo and Juarez, 1985).

This model has been progressively adopted by other countries in the Central American region but, just as in Guatemala, the potential impact of the model has been restricted by the research/extension gap. The need for a new methodology for massive diffusion of new technology is evident.

A new effort has been made and a project for technology transference, following the fundamentals of the FSR/E approach, has been designed in Guatemala. The project is based on a model known as the Modular System for Technology Transference, which has its origin in working experience that ICTA had in the Guatemalan highlands (Waugh, 1980; Whyte, 1981) and will provide the opportunity to the research and extension agencies to participate together in a joint effort for the generation and transference of appropriate technology for small, family farms.

THE RESEARCH/EXTENSION SYSTEM IN GUATEMALA

The research and extension system was adopted by the Ministry of Agriculture of Guatemala in 1954. This decision was financially supported by the U.S. government through the program for technical assistance, and it was designed

following the same concepts of the research and extension system of the land grant universities in the U.S. The organizers tried to adapt this system to the local conditions, but the university did not participate and the administrative structure stayed within the rigid bureaucratic framework of the ministry. Besides the lack of specialized and motivated technical staff that would generate technology to support the extension activities, there was never a serious effort to establish a constructive dialogue between research and extension, even though both activities were under the same institution. Relative to the research conducted, technology was generated mostly in experiment stations under conditions that contrasted strongly with those existing in small, limited resource farms. There was hardly any impact on production, consumption began to exceed production, and the country was forced to resort to frequent imports of basic grains to satisfy the national consumption requirements.

The continuous inefficiency of the research/extension system during the 50s and 60s, as it was adapted and structured in Guatemala, led the authorities of the Ministry of Agriculture to reexamine and define the causes contributing to this failure. A critical analysis of the work conducted made some faults evident within the adopted system (Waugh, 1975):

a. Failure to recognize the agro-socioeconomic factors that limit the production efforts of the small farmers; furthermore, there was hardly any knowledge on their crop systems, needs and preferences, available resources, and expectations;

b. There was no agroeconomic field data supporting the recommendations that the extension agents could use for specific conditions;

c. Farmers had no participation, whatsoever, in the technology innovation process; researchers did not consider the needs and expectations of those farmers when planning "their" research, and farmers were not included in the evaluation of new technologies;

d. Lack of competent professionals in the research and extension activities, and also lack of incentives and motivation for the technical staff in the system;

e. Difficulty in working within a rigid bureaucratic environment subjected to political turnarounds and without the opportunity of making decisions that could be promptly executed for the good and normal functioning of the system.

Through the identification of the deficiencies in the system, it was determined that the interrelationship, farmer-extensionist-researcher, would be indispensable for planning and conducting a program of technology generation and validation that would be suitable to the needs and resources of farmers. This interrelationship would also be necessary to ensure an effective transference process of new technologies.

The next step, as part of the solution to the problem previously described, was to establish a new research institute (ICTA), autonomous and

with enough budget, oriented to the identification and solving of agricultural production problems that small, limited resource farmers face. Its organic law assigns ICTA the responsibilities of academic training of its technical staff and the promotion of new technologies. The Rockefeller Foundation and the Agency for International Development (AID) supported the establishment of this new research institution.

A NEW RESEARCH APPROACH FOR TRADITIONAL AGRICULTURE

Since its beginning, ICTA committed itself to increase agricultural production and improve the productivity and well-being of the people in the rural areas. This would be achieved by using the scientific method as an effective tool to generate appropriate and economically favorable technology that would not involve a larger risk to the target group for whom the technology would be generated. The most relevant aspects within this new approach are the following (Ortiz, 1980):

1. A thorough knowledge of the agro-socioeconomic conditions of the farmers in a region would be required, and it is obtained by integrating biological and social scientists in regional multidisciplinary teams that identify farmers' resources and constraints in order to generate appropriate technology for those conditions.

2. Most of the research activities would be moved off experiment stations to farms, where they are to be conducted under the farmers' conditions. New technology is then generated under location specific conditions, giving it reliability in terms of appropriateness and precision, since the variability within and between sites has been sampled.

3. The involvement of farmers in all the phases of the technology innovation process, giving them the main role in the final stages of evaluation of new technologies; here, they decide whether the technologies are accepted or rejected, and their decision is to be respected. This is the major and most important change from the previous approach.

ICTA's officials did not consider technology generation as the ultimate objective; they felt that the institutional commitment should be to identify and put into practice transference procedures and methodologies to promote the use of appropriate technologies by farmers. For this purpose, inter-institutional linkages with the extension agency, Directorate of Agricultural Services (DIGESA), were developed, collaborative efforts were established with cooperatives and other farmers' groups, and a strong support was given to the private sector to promote a strategy for seed production and commercialization that was successful (Ortiz, 1980; Castillo and Juarez, 1985). Less than ten years after ICTA was founded, Guatemala had registered significant increases in basic grains production that covered the deficit of previous years and have since then, along with oilseeds (sesame), provided exportable amounts that improve its international

exchange balance (Castillo and Juarez, 1985).

THE RESEARCH/EXTENSION LINKAGE

With the new research approach and a renewed interest in promoting the use of appropriate technology, ICTA and DIGESA, the extension agency, signed a letter of agreement in 1978 that would expedite the joint activities of those institutions for the purpose of technology transference.

The most significant of these efforts, in terms of success, have been the courses for inter-institutional technological linkage that provided the extension agents with the opportunity to participate in on-farm research activities. With their involvement in the technology generation process, the extensionists improved their effectiveness in promoting the use of new technologies (Ortiz, 1980).

But still, the degree of effectiveness in technology transference has not been considered adequate. Technology has been reaching the farmers, but not in the same intensity in each region or in every group. In spite of the inter-institutional efforts for the promotion of new technologies and the evident impact of these technologies on food production, there remains a group of factors hindering the diffusion of technologies to a larger number of farmers.

Among the various reasons for the "limited" diffusion of technology, the most important is that technology transference programs have not been, technically and administratively, designed and executed properly. They lacked qualified personnel; adequate functioning regulations; financing for needed equipment, inputs, and personnel, and an efficient operational methodology to reach a significant coverage. Another important reason limiting the strength of these efforts has been that extension agents were restricted, in most cases, to credit planning and supervision and not enough time to be trained in and communicate new technologies.

In preparing for a new effort in technology transference, the Agricultural and Food Public Sector (SPADA) of Guatemala accepted the fact that a new "attitude" was necessary in the design of the project. This new attitude consists of letting farmers <u>participate</u>, rather than be <u>educated</u>. That is, the extension effort to educate farmers and their families would be substituted, for technology transference purposes, by joint participation of farmers, extensionists, and researchers in all the phases of the technology innovation process.

This paper presents a description of this new effort for a wider diffusion of new technologies. Three institutions of SPADA prepared and will conduct this technology transference project: ICTA, DIGESA, and the Directorate of Livestock Services (DIGESEPE). This last institution is the extension agency for animal health and production. The project has recently been approved to be financed by the Inter-American Development Bank (BID Loan 473/OC/GU) and the International Agriculture Development Fund (FIDA Loan 154 GM) and will begin its activities in 1986 in three regions of

Guatemala. The basic features in this transference effort are the following:

1. For this specific project, a "new" extension agent (AG-promoter) within DIGESA and DIGESEPE will be trained and dedicated to technology transference activities. That is, the new research approach has been accepted and a new extension approach is adopted;

2. There will be a joint participation of researchers and AG-promoters in the generation, testing, and promotion of new technologies. This will provide an excellent training for the "new" extension agents in the knowledge and management of new technologies;

3. Rural leaders (AG-leaders) will be recruited and their salaries paid by the project, and trained by the AG-promoters in the management of new technologies. These AG-leaders will be in charge of promoting new technologies among organized groups of farmers in the communities;

4. An effective transference strategy through the establishment of a Modular System, and

5. The participation of farmers throughout the whole technology innovation process.

A NEW MODEL FOR TECHNOLOGY TRANSFERENCE

The flow chart of a modular system for technology transference (Figure 1) illustrates the new research/extension linkage concept for a faster, wider coverage and more effective technology transference. This model is the essence of the new Project for Crop/Livestock Technology Generation and Transference and Seeds Production (PROGETTAPS) that will be conducted by ICTA, DIGESA, and DIGESEPE in three regions of Guatemala beginning in 1986.

In this flow chart (Figure 1), which is an expanded version of ICTA's Agricultural Technological System (Fumagalli and Waugh, 1977), the first two stages: research on experiment stations and on-farm trials, are the responsibility of the research teams and are conducted in the same fashion as ICTA conducts its work; but in this case, the AG-promoters from DIGESA and DIGESEPE will be involved in the system, especially in the agro-socioeconomic evaluation of on-farm trials. From this stage on, already familiar with ICTA's new technologies, the AG-promoter takes over the training of rural leaders (AG-leaders) in the concept of the overall transference strategy and in the management of the technological innovations. These AG-leaders will be prominent farmers that are well-known and respected in their respective communities.

Within the project, the rural leader constitutes the key element in the technology transference process. Through their influence with farmers and working with groups, the expected multiplying effect could be obtained. These AG-leaders will be coordinated and constantly oriented by the

AG-promoters, who will have the continuous technical/scientific support from ICTA's field teams (Technology Testing and Transference Teams).

The new technologies will be promoted in "transference plots" conducted by the AG-leaders on their own farms and farms of collaborators. These plots will be used to irradiate technology to groups of farmers in each community, using a mixture of methodologies used in the research/extension system as transference activities, such as visits, seminars, field days, technical meetings, production clinics, participative work, and demonstration methods.

By establishing this model, it is expected that the research will be responsible not only for technology generation, but also for promoting its use. On the other hand, the "new" extension agent (AG-promoter) will be responsible for technology transference and will collaborate closely with the researcher in the technology generation and promotion acitivities.

ORGANIZATION AND FUNCTIONING OF PROGETTAPS

ICTA, DIGESA, and DIGESEPE will be jointly responsible for the organization and operation of the Modular System for Technology Transference (MSTT) within the new project, PROGETTAPS. The various modular systems will operate under this directive inter-institutional nucleus, and the number of modules within each system will vary from region to region. The module is the basic unit and the system has as many modules as it is feasible to establish within a given region or subregion.[1]

Each module (Figure 2) will be integrated by a "tecnico"[2] of ICTA's Technology Testing and Transference Team (4 T's) in the subregion, with logistic support from ICTA's regional team, one AG-promoter, and 10 rural leaders. This researcher will have two responsibilities: generate technologies and promote their use through the training of the AG-promoters in the characteristics and management of these technologies. The AG-promoters have already been trained in activities of formation (youth clubs), motivation, and promotion. This fact makes possible that the AG-promoters may work with different groups or categories of farmers. These "new" extension agents will participate with the researcher in conducting researcher-managed and farmer-managed on-farm trials; they will also participate in the planning of the research activities, make AG-promoters active participants in the generation of technology, motivate them in understanding the whole system and the role they play, and give them full knowledge of the characteristics and management of new technology to increase their effectiveness in promoting its use.

Each AG-promoter will be responsible for the training of 10 rural leaders in the new technologies in coordination with "tecnicos" of ICTA's 4 T's. These AG-leaders will be hired and paid by the project and recruited based on their degree of leadership within a community, geographical location within the area of the project, land ownership, and, whenever possible, ability to read and write. The main activity of these rural leaders will be to organize a group of 20 farmers and conduct "transference

plots" on his farm, and on their farms. These transference plots will be the field laboratories where farmers will have the opportunity to observe and learn by themselves the results of using technological innovations which are based on their needs and available resources. The inputs and labor in the transference plot are the responsibility of the owner of the farm where this is conducted, just as in the farmer-managed trials that ICTA's 4 T's conduct (Ortiz, 1980).

The described module covers 200 farmers, but its potential is larger. Just by increasing to three the number of AG-promoters to enlarge the multiplying effect, the number of farmers directly exposed to new technologies will reach 600 (Figure 3). The desired coverage will be a function of the number of established modules, which, in its turn, will be determined by size of the area, number of farmers, infrastructure, and available resources for the project in that given area. It is estimated that each modular system will reach 7,200 farmers. The project includes the establishment of four modules and will finance activities for four years. This means that 115,200 farmers are expected to be reached directly by new technologies.

Monitoring and feedback will be important activities during the process, and the participation of researchers, AG-promoters, AG-leaders, and farmers is included. For those purposes, there will be technical meetings, programmed visits to transference plots, and the annual presentation of results and planning of activities for the coming cycle. The final evaluation of the project will be conducted by ICTA, DIGESA, DIGESEPE, and the Sectorial Unit of Agricultural Planning (USPADA).

ESSENTIAL CONDITIONS FOR PROJECT SUCCESS

PROGETTAPS, as any other development project, requires a high degree of coordination and cooperation among institutions if the established objectives and goals are to be reached. This is particularly true, even more so, when trying to conduct projects of inter-institutional nature where it is often necessary to establish priorities among activities based on available resources. For this reason, SPADA has established certain criteria or regulations that are necessary to consider before the approval of inter-institutional projects.

These essential conditions for inter-institutional projects are the following:

1. The involved institutions must make a formal commitment of active participation throughout the project;

2. There must be common objectives that guarantee the institutions' interest to participate and keep participating, even after the project is over;

3. A uniform work methodology that expedites the conduction of the different activities within the project;

4. Integrated work plans within the project and a well-defined organizational structure that determines the functions and responsibilities of the participating institutions;

5. Establish monitoring and evaluation activities for each stage of the project, and

6. Adequate financing throughout the project life.

All these actions are foreseen in the development of PROGETTAPS, and their inclusion gives strength to the project and in a high degree guarantee its success.

Footnotes

[1] ICTA's Technology Testing and Transference teams operate at a subregional level. Region and subregion are political/geographical divisions used by the Agricultural and Food Public Sector.

[2] The "Tecnicos" from ICTA's 4 T's are mostly university graduates, and most of them are agronomists.

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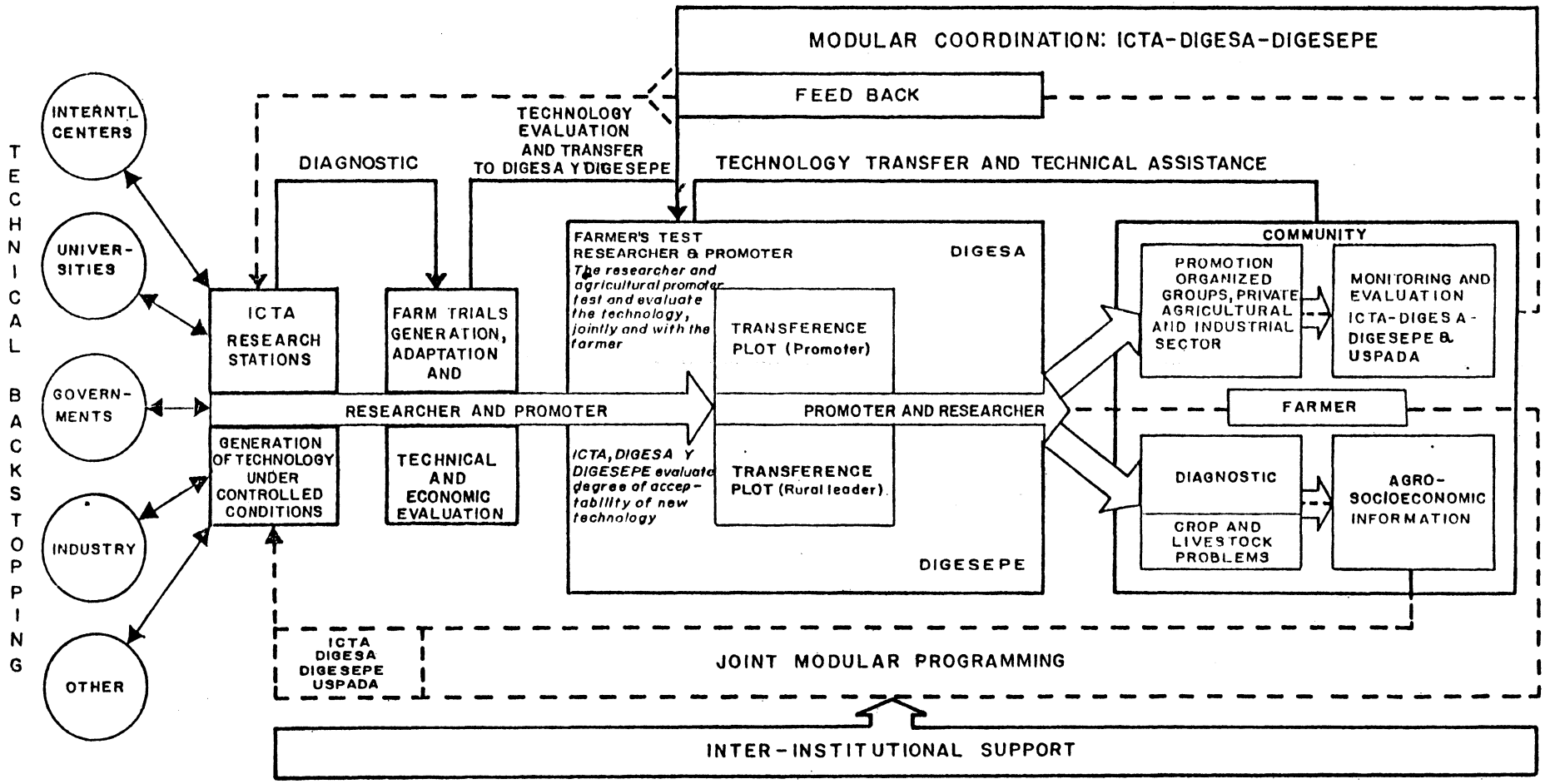
FIGURE 1

A FLOW CHART DIAGRAM OF A CONCEPTUAL FRAMEWORK FOR TECHNOLOGY TRANSFERENCE IN A MODULAR SYSTEM



Source: "Generación y Transferencia de Tecnología Agropecuaria y Producción de Semillas (GU-0065)". Informe de Proyecto. Banco Interamericano de Desarrollo, PR-1350-A, Guatemala. Mayo 1, 1984.

FIGURE 2

BASIC UNIT OF THE MODULAR SYSTEM

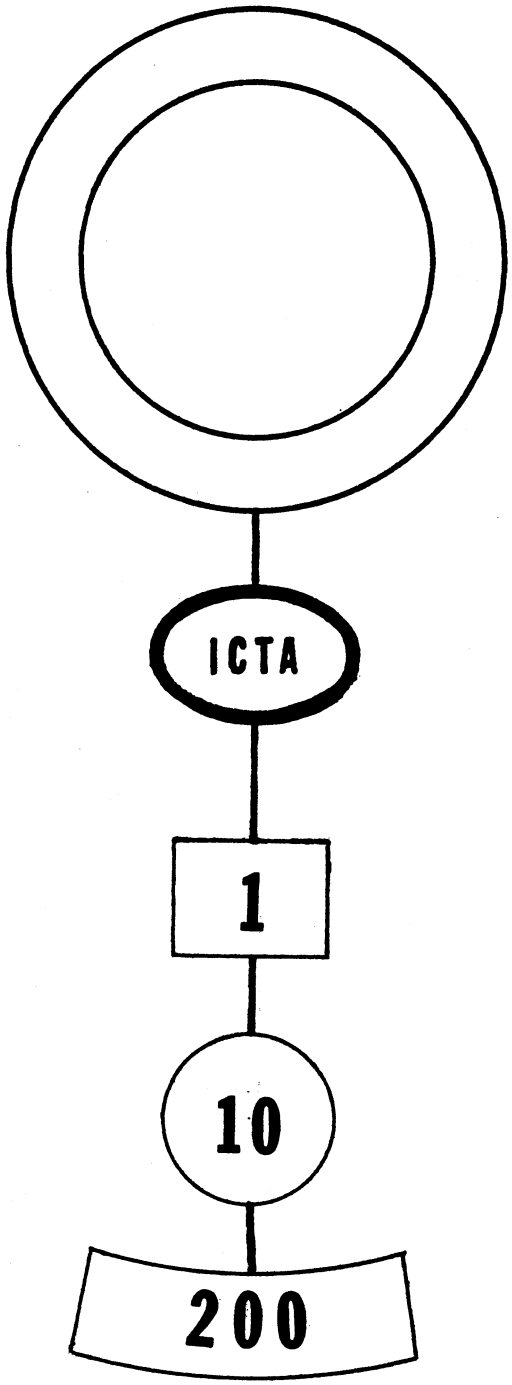
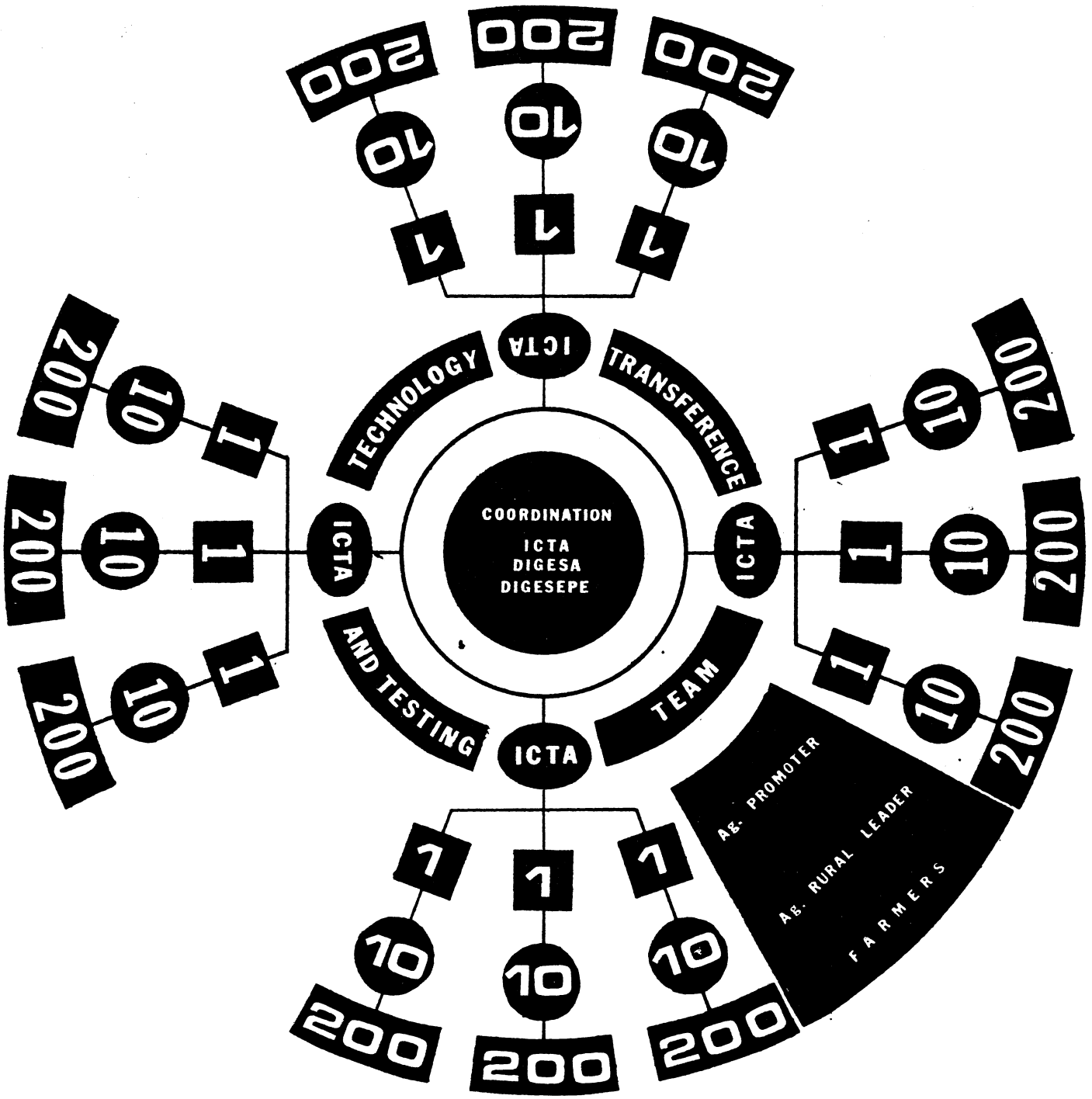


FIGURE 3 MODULAR SYSTEM FOR TECHNOLOGY TRANSFERENCE



USING MALE RESEARCH AND EXTENSION PERSONNEL TO TARGET WOMEN FARMERS

Anita Spring

> A group of people en route to the FSR Conference met a child with a wagon load of puppies. One of them asked where the child was taking the puppies and the child answered that the puppies were going to be given to the commodity researchers (this was a sophisticated child). The next day, after the conference had started, the participants were en route to lunch and they came across the same child again. One of the participants introduced the child to some people who hadn't been there the day before and asked the same question about the fate of the puppies. This time the child said the puppies were being taken to the farming systems researchers. The participants pointed out that only yesterday the child said the puppies were going to commodity researchers. "But," the child replied, "yesterday, the puppies didn't have their eyes open."

INTRODUCTION

To many FSR proponents, commodity-oriented scientists do not focus on the whole farming system and therefore do not have their eyes open. They cannot appreciate the complexities of small farm management and smallholder needs and problems. This is analagous to the way those involved in farming systems research and extension (FSR/E) feel about the lack of appreciation and consideration of gender issues and intrahousehold dynamics amongst FSR&E practictioners. Those who ignore these issues do not have their eyes open. Farming systems researchers did not invent the fact that farmers have to deal with a multitude of environmental, familial, infrastructural, and other factors, so that a focus on a single commodity might not remedy the problems of the farming system. So too, researchers who consider women's role in agriculture did not invent the sexual division of labor, the semiautonomous nature of different family members, the differential access to land, labor, and capital, or the fact that women are becoming more involved in the smallholder sector in some developing countries because of extensive male migration (Chaney and Lewis, 1980; Gladwin et al.; Dixon, 1982).

Evidence is accumulating that technology transfer is frequently hindered when intrahousehold dynamics are not taken into account (see for example Rogers, 1979; McKee, 1984). Often, technologies are ill-suited or only partially adopted because the resource base in terms of personnel, capital, land, and equipment is inappropriate or inadequately understood. A consideration of intrahousehold labor allocations and decision-making shows that in many places female family members will have to provide the labor and will either make or be involved in the decision as to whether or not to adopt the technology. In addition, labor, access to resources, and remuneration are not consolidated in one neat family unit everywhere in the world, but often are dispersed among

individuals who are in diverse age and sex categories. A failure to look at who does what farm operations, who makes which decisions, and who receives the remuneration, and makes further investments, will affect the practive of FSR/E. For example, a higher yielding variety might require more labor in managing, harvesting, processing, and storing the cereal especially in synchronously maturing varieties (Ferguson and Horn, 1985; McKee, 1984) or a livestock intervention might target one group of producers at the expense of another. For example, in a case from Senegal, men made decisions about the planting of cereal crops, but women contributed much of the labor for the crop's weeding, harvesting, and processing. Women made decisions about legume, vegetable, and condiment crops. If women did the extra work for the new variety of cereal crop, they had less time for the crops that they managed. In livestock production male farmers favored livestock interventions that "would increase live-weight and quality of stock" because size and number were determinants of wealth. But, women controlled the milk allocation and sale of milk products and "would gain most from interventions which increased calf survival or ...permitted an increase in the number of animals under current land or labor constraints" (McKee, 1984:598-599).

There are specific methodologies needed to understand intrahousehold variables within the FSR/E process (McKee, 1984). In the pre-diagnostic stage, the ethnographic literature that provides information on the household's division of labor, decision-making, and allocation of resources must be reviewed for specific recommendation domains. In the diagnostic stage, the types of household and the types of representative farmers need to be considered. For example, in areas where there are many households headed by women, as in the case of much of Africa and the Caribbean, it is necessary to include such households in the sample and to ask if their resources and needs are the same as or different from the households headed by men. Socioeconomic and agronomic variables have to be assessed in terms of various household members in the different types of households. The interventions have to be geared to the needs of the types of households and the constituent members. In the technology design stage, it is necessary to make sure that the researchers do not use incorrect assumptions about gender; McKee suggests the input of female scientists and field workers, but this is not always possible or even a guarantee tht gender issues will be considered. There is no reason why both male and female scientists, who have their eyes open, cannot work on the problem. In the testing stage McKee says that one must monitor "how the farm household actually copes with the reallocation of resources required by the new requirements" (McKee, 1984:602). In the final extension stage, McKee argues that it is important "to involve women farmers and farm workers, as well as female extension agents, in diffusing technologies for crops and tasks in which women predominate" (McKee, 1984:602).

The major thrust of this paper is that men as well as women agricultural researchers and extensionists have to become involved and have to target farmers of both genders. The argument here first considers the gender-related characteristics of extension services and how these characteristics affect reaching a variety of farmers, especially women. Then a case study from Malawi shows that women are important in agriculture but tend to be neglected in extension services and in the practice of FSR/E. In order to study and correct the problem, the results of two sets of trials are considered here. In one analysis, the results of using men and women farmers in the sample shows differences in recommendation domains. In another, mechanisms by which the male staff can work with women farmers are discerned. Based on the

lessons learned the paper concludes with a mechanism whereby the male extensionists were legitimated and mandated to work with female farmers.

CHARACTERISTICS OF EXTENSION SERVICES

Usually it is the male extension personnel who work with farming systems researchers to locate, interview, select trial cooperators, and target disseminators. The number of male extension workers far exceeds the number of women who receive training and who are employed as extensionists in most places. Many writers comment on the paucity of female extension workers compared with male ones (Jiggins, 1984; Berger et al., 1984; Staudt, 1975-76, 1978; Fresco, 1984). The data show that worldwide (including North America and Europe) only 19% of the agricultural extension staff members are women. The average number of female extensionists for Africa is 3%, for Latin America and the Caribbean it is 14%, and for Asia and Oceania the figure is 23%. Only in the Philippines are 40% of the staff members female. Table 1 gives the figures as of 1981 for these regions. Berger et al. (1984) estimate that of extensionists specially designated as agriculturalists, 41% do home economics rather than agriculture. Tables 2 and 3 show the number of men and women trained in two countries where women are critical in agricultural production: Malawi in Africa and Nepal in Asia. These tables show that women extensionists also are to be found in the bottom education tier and that their training is much shorter than the training for men. A consequence of this is that women extensionists often are not regarded as professionally competent in their knowledge of field crops and of livestock as men. What is not evident in the tables is that female workers are often pressured to work in home economics programs rather than to work in the agricultural programs for which they were trained. The contacts of female workers with male farmers tend to be limited; concomitantly, the male extensionists tend to deal with male farmers rather than with all farmers (Jiggins, 1984, Part 3:16). Whereas it is often the case that only a small proportion of farmers are reached by the extension service in any case, there is no reason to restrict extension to only male farmers.

In the extension service itself, male personnel hold a variety of positions, including decision-making ones that affect programs and policies. The female extensionists, with the exception of a few supervisors, usually are concentrated in the lower ranks. Often male workers are given the tasks of offering concrete agricultural services either through the training and visit system or through other regimes, while the female workers are supposed to form women's groups for small scale income generation activities. Most extension services in developing countries were modeled after the systems in North America and Western Europe during the colonial period with men providing agricultural information to male farmers and women providing home economics and nutrition information to women (Mead, 1976; Berger et al., 1984). Ironically, home economics programs in the developed countries have changed a great deal since the late 1800s and have become relevant to the needs of American farm women today, focusing on such topics as human development, consumer education, household finances, and marketing. By contrast, the teaching of domestic science in Africa is mostly focused on sewing, embriodery, recipes, and basic hygiene/nutrition. Coupled with this is the notion that there is better communication between members of the same sex than between members of the opposite sex. Sometimes these notions are strongly stated in terms of tradition or cultural constraints and operationalized so

that only women are slated to work with women and only men are slated to work with men. The paucity of women in agricultural service assures that rural women will remain uncontacted and unassisted in terms of mainstream agricultural training and services. Although it is probably true that many people prefer to learn or to work with people of their same sex, coeducational programs have worked in a large portion of the world. Berger et al. remark that "since very little empirical work has been done in this area, there is really no basis on which to judge the relative effectiveness of men and women agents in assisting women farmers" (1984:54).

The Integrated Cereals Project in Nepal funded by USAID studied women's contribution to agriculture in four areas of the country and queried how women farmers could most effectively be reached (Shrestha et al., 1984). In this case because of women's important role in the agricultural system, it was "posited that unless new information, methods, and techniques are made available to women, major potential change agents in the agricultural labor force are being by-passed" (Shrestha et al., 1984:6). When questioned, the women farmers said they did most of the agricultural work (79%) and more than a third (35%) of the decision-making (Table 4). The female extensionists agreed with the female farmers but the male extensionists thought women did only some of the work and were not involved in decision-making. The male workers were therefore "unlikely to perceive female farmers as important recipients of extension information" (Shrestha et al., 1984:29) and this undoubtedly constrained their contacts with women. Concomitantly, female farmers did not think of themselves as recipients of extension information. However, there were contacts by male extension agents to family members as reported by female farmers. The data showed that three fourths of the male extensionists did talk with women but only sporadically (about only 16% of their contacts are women); and one fourth never contacted women (Table 5). Female farmers were asked if they would visit male and female extensionists. Table 6 shows that almost all the women farmers said they would seek out a female extensionist and would go to their homes for advice, a common practice of male farmers towards male extensionists. Fewer would ask a male extensionist or visit their houses. Yet, in the areas where fewer women would contact the male extensionists, male extensionists had visted the women. This case illustrates that people prefer to work with people of the same gender, but in practice farmers work with those who have the knowledge, power, and access to resources. It should also be mentioned that only 2.5% of all extension workers in Nepal are female, so the possibility of having a woman agent nearby is remote.

Because of the polarization of the extension service in many places, there is little or no way to account for the variety of real situations and to take into account the needs of the various household members. Some households may share resources well and have a division of labor that is complementary. There are households where husbands may preempt resources that other household members helped to generate. In some households both husband and wife are full time farmers; in others the husband may be absent and may or may not send remittances while the wife does the farming; in still others a woman will have no male labor or support; in some households only the husband will farm or the wife is a part-time assistant. These varieties of intrahousehold dynamics and access to services and resources by different family members have to be considered in the design of technology testing and dissemination.

Part of the reason that it is difficult to reach the women in the practice of

FSR/E is that researchers make use of the extension and research services as they are already set up in the host country. Farming systems researchers accept the bias of the system either because they do not recognize it as such and/or because it coincides with their own. In recent years there has been a reexamination of the assumptions behind the sexual seggregation in extension and research programs. In a number of places, the policies have become non-discriminatory so that technically women farmers can apply for credit or they can be part of FSR/E programs, although in practice the number of participants is low (Delancy, 1984). The question to be asked is what would happen if the equation were changed and if extension and research programs in practice were geared to all farmers regardless of sex. This might even entail new procedures to target and reach the neglected farmers rather than the standard procedure of assuming that one method works for all. A case study from Malawi examines the problem of relying on male extensionists in FSR/E and reports on some methods that were undertaken to change extension and FSR procedures in order to reach female as well as male farmers.

CASE STUDY FROM MALAWI

Between 1981 and 1983, I directed an agricultural development project funded by the Office of Women in Development and housed within the Ministry of Agriculture in Malawi (Spring, 1985). The Women in Agricultural Development Project (WIADP) was of national scope and its aims were multifaceted: to research women's and men's roles in smallholder farming; to use farming systems research to ascertain smallholder, and especially women's needs; to disaggregate agricultural data by sex; to work with extension and research units to target women as well as men farmers; to evaluate women's programs; and to orient policy makers to consider women farmers in agricultural programs. Primary and secondary research by the WIADP showed the contributions by gender for various commodities (Clark 1975; Spring, Smith and Kayuni, 1983b). Women indeed did form the bulk of the agriculturalists in the rural areas. They spent as much time on their farm work as on their domestic work. Approximately one third of the households in the country were headed by women, but in some areas as many as 45% of the households were female headed. Women were taking over more of the management of family farms. This was true not only in households that they headed, but in married households because of male out migration for wage labor in cities and in the agricultural estate sector. Women were involved in a variety of cropping patterns from mixed subsistence to cash crops. They grew maize, groundnuts, rice, cassava, tobacco, cotton, coffee, and tea. They worked on both food and cash crops doing many of the operations such as spraying cotton and planting tobacco seedlings that were commonly believed to be done by men only (Clark, 1975). In fact, farm operations were differential by sex in some areas and in some households, while in other places and households they were not. The so called standard sexual division of labor where men prepared the land and women planted, weeded, and harvested had given way to expediency in many places (Spring, Smith and Kayuni, 1983b). The adult who was home on the farm did the operations and in many cases this meant that the women were doing the work and making the farm decisions. Women were involved in all aspects of farming including land clearing, plowing, applying fertilizer, crop protection, etc., either routinely or when male labor was unavailable. Women in many areas were involved in the care of livestock, especially of small ruminants and poultry. Free ranging cattle were mostly owned by men and cared for by boys and men, but as the animals were brought into the village for fattening in

stall-feeding projects, their care fell to women (Spring, 1986a).

Agricultural development projects increased the amount of time in hours per day and in days per month that both men and women had to work (Clark, 1975). The agricultural services provided by integrated development and localized projects that included such services as training, input, and credit programs, and agricultural extension mostly by-passed women. For many households this meant that the efficiency of their farming was reduced. There were some women who were able to participate in development programs in order to increase their productivity. There were some male extensionists who included women farmers with the male farmers they targeted for training, credit and visits (Spring, Smith and Kayuni, 1983b).

The WIADP documented the delivery of agricultural extension services to men and to women in a variety of ways. First, the WIADP analyzed the extension survey that was part of a large national multi-instrument survey conducted by the Ministry of Agriculture and financed by the World Bank. Second, the WIADP interviewed and observed extension personnel in the field in terms of the way they worked with clients. Third, the WIADP conducted FSR/E surveys and trials and studied the ways the extension personnel were utilized to identify and to work with farmers. Fourth, meetings and interviews were held with the staff and management of agricultural projects who supervised extension and research efforts to examine their procedures.

The results from the national survey (The National Sample Survey of Agriculture or NSSA) showed that farmers' contact with extension workers in terms of personal and field visits, attendance at group meetings and demonstrations, and participation in training courses were differential by sex (Table 7). The data showed that contact with extension workers was the major source of advice for both men and women farmers, but that men received more personal visits and more advice than women. Group meetings tended to reach more farmers than personal visits, but men were the primary participants. Relatively few farmers of either sex viewed extension demonstrations, but more men than women learned from this method. Field visits reached even fewer women and the WIADP observed that many male extensionists simply dismissed the women working in the fields while they concentrated on the men.

The WIADP disaggregated the NSSA data into three categories: male household heads, female household heads, and wives of the male household heads. The data showed that men received more services than women and often wives received more services than female household heads. The data also showed that very few wives received agricultural information from their husbands. The presumed transfer of technology from husbands to wives and from men to women in the household did not take place. The asssumption that if men are trained or assisted that other family members learned or were assisted was not confirmed by the data (Spring, Smith and Kayuni, 1983b).

In terms of the practice of FSR/E surveys and trials it was the uncommon situation where women farmers were contacted by reconnaisance or survey teams or where they were part of the recommendations domains discerned. There was a tendency for the host country and expatriate researchers to ignore the women in the fields during rapid reconnaisance surveys. When production and social scientists relied on the extension workers, which they often did, the extension workers tended to take them to interview and work with the men. In terms of on-farm farmer managed trials, only male cooperators were selected.

Sometimes the male cooperators carried out trial work themselves. Other times their wives and female relatives assisted or did much of the work, sometimes producing errors in the way the trials were conducted. (This is probably because these women had not received the instruction and the male cooperators did not pass on the information.) In order to understand the problem, the WIADP asked trial cooperators who actually carried out each operation. The information obtained showed that wives and female relatives performed many of these tasks (Spring's notes from Kawinga and Phalombe FSR surveys).

The WIADP participated in several attempts to remedy the way in which surveys and trials were conducted. Concerning surveys, the WIADP conducted its own FSR/E surveys in three different regions of the country and worked with a USAID and a German team in Central Region (Spring, 1982; Spring, Kayuni and Smith, 1982; Spring, Smith and Kayuni, 1983a). Each time, there was a tendency on the part of the male extension workers who accompanied the teams to direct the teams to the better male farmers. In order to remedy the situation, it was explained to staff and team members that it was necessary to examine a range of environments, family types, and economic situations. Occasionally, it was necessary to refuse to meet only with the better male farmers. The WIADP prepared guide sheets that detailed the types of households and families that needed to be considered and requested that the following categories of farmers be sampled by teams doing the diagnostic survey:

1. A diversity of economic situations: low resources farmers, including those who must work for others; subsistence farmers; and wealthy farmers who grow cash crops and hire laborers.

2. A diversity of household types: families composed of (a) a wife, husband, and children; (b) a husband, two or more wives, and children; (c) a married woman with children, but the husband was away; and (d) an unmarried woman and children.

3. A diversity of ages and life cycle situations: older people, recent widows, and widowers; young couples just beginning to farm; long time farmers; and women recently divorced or on their own (Spring, 1982).

It also helped to have women researchers and extensionists on the teams, and subsequently it became fairly standard practice to have women on FSR/E teams. (The new program of FSR/E using adaptive research teams in the country specifies that there should be a woman on each team (Kay Pasley: personal communication).

Concerning trials, the WIADP conducted its own and worked with another USAID project on its trials (Hansen, 1986). Two examples of trials that included female farmers illustrate the problems in obtaining women cooperators as well as the lessons learned by considering women. The first example concerns trials held in a low resource area, where there is land shortage and a drought-prone climate, and where 37% of the households were headed by women. Average holding size was one hectare, but more than 60% of the households cultivated less than a hectare and almost a third cultivated less than half a hectare. Male out-migration was pronounced and women and children remained to work family farms. The trials consisted of comparing an improved cultivar with a local variety with "a simple nonreplicated 2 x 2 factorial arrangement

with two maize varieties and two levels of fertilizer (0 and 30 kg N/ha)" (Hildebrand and Poey, 1985:127-8). Since area farmers intercrop, all the treatments had a mix of maize, cowpeas, and sunflowers (Hansen, 1986).

It was specifically requested to the village headmen and the extension workers who selected the farmers that half of the cooperating farmers be women. However, only 40% of the cooperators selected in one village and 30% in the second village were women. In a number of cases the women and the men farmers selected were not comparable as farmers. The men tended to be vigorous individuals in their middle years and many were high resource farmers who owned cattle. Most of the women tended to be low resource, older individuals at the end of their life cycle. They were probably selected because age is revered and it was considered an honor to be selected, perhaps more so for women than for men. Therefore, comparisons between male and female farmers in terms of management and yields would not be valid to show gender differences in farming (Table 8).

The data do show differences between high and low resource farmers and more women are in the latter category. A modified stability analysis was carried out on these data by Hildebrand (Hildebrand and Poey, 1985:126-34) and by Hansen (1986). Because of the inclusion of a range of farmers, young and old, male and female, an evaluation of the types of evironments could be made where "environment...becomes a continuous quantifiable variable whose range is the range of yields from the trial" (Hildebrand and Poey, 1985:126). The analysis showed that in the same area there were a range of environments in terms of farmer management, soils, rainfall, and the like, and that the cultivars respond differently. The local cultivar was superior in poor maize environments while the improved maize was superior in "good" maize environments (Tables 9a and 9b). Both cultivars responded "favorably to fertilizer in both good and poor environments" (Hildebrand and Poey, 1985:129). The data showed that there were two different recommendation domains. Although there were both men and women in each domain, there was a tendency for the women farmers to be in the poorer environment most likely because they were low resource farmers to begin with. Further analysis using confidence levels allowed the high and low environment farms to be compared. The results showed that only farmers in the better environments should choose the improved variety (the composite) and that they should fertilize the crop (Table 10a). In the poorer environments, the local variety was better (Table 10b). Fertilizer helped, but should only be recommended to farmers who could afford it. The final recommendation was "to fertilize the local maize variety in the poorer environment and to use the composite maize with fertilizer in the better environment" (Hildebrand and Poey, 1985:132). It should also be mentioned that farmers who owned cattle and used the manure on their fields were in the better environments. Women did not own cattle too frequently, although the one high resource farmer in the sample did.

By comparing people at different ends of the spectrum, two recommendation domains were discernable. All but one of the farmers in the better environment were men. Most of the farmers in the poorer environments were women, although there were some men. This showed that recognizing different segments of the population, including those at particular risk, resulted in the delineation of multiple domains and technology solutions in this case. The female headed households constrained by labor and cash would find it difficult to use fertilizer and this coupled with their smaller holdings and lack of extension advice would make their use of the improved cultivar

disasterous. (Where men and women farmers are similar in their access to land, labor, and capital, gender probably would not be a factor in recommendation domains.)

Should these low resource households be ignored? Another study on these households documented that they were being ignored by extension and credit programs (Evans, 1981). To remedy the situation, methods were devised by a British researcher that involved several steps. First, the cooperation of male extensionists and male village leaders was required to bring women into the extension arena and to enable them to articulate their problems. Second, the notions of credit "worthiness" had to be changed. Finally, the actual credit packages had to be modified. To do this, male village leaders were asked to designate women farmers for leadership training. The women were taught leadership skills by both male and female extension personnel. Then they were able to articulate their problems in farming. In general, they noted that extension services by-passed them in terms of credit and training. In particular, it eventually became clear to the male staff members that, because of the women's small land holdings and because of their risk-averting practice of intercropping, the standard credit packages of improved seed and fertilizers (in multiples of one acre) were too large. The solution to credit services by-passing women was to instruct the male as well as the female staff members to target women. But a method of determining "credit worthiness" (usually defined by collateral or membership in the mostly male farmers' clubs) had to be devised and a way to pay back the cash for inputs had to be found. These women were not members of farmers clubs organized by the male workers and lacked collateral so their "credit worthiness" was nil. A new method was devised in which they could be vouched for by male village headmen. Also it was unknown as to how these women would pay back the loan. These households would have no cash sales, because the inputs were helping them to attain food self-sufficiency. It was known that women are particularly concientious about repaying loans. The women, much to everyone's surprise, began paying back the loan from the sale of beer and crafts even prior to the harvest (Evans, 1983).

The solution to the actual credit package itself was the creation of mini-technical packages (of 1/2 acre) of fertilizer and seed. With the assistence of the male extension staff, the number of women getting credit in the project increased from 5% to 20% of the credit recipients in a single year. These households went from food deficient to food self-sufficient households. However, nonstandard techniques had to be used and the male extension staff members were important to the success of the endeavor.

The second example of using women as trial cooperators concerns demonstrations and trials with soybeans (Spring, 1985; 1986b). In this situation, women were targeted through their home economics classes to learn the recipes for using soybeans. The Ministry of Agriculture determined that this crop would improve the rural diet that was deficient in fats and proteins. The female staff members were used to reach the women and they only taught recipes but not methods to cultivate the crop. (The female extensionists did not know how to grow the crop and lacked training on rhizobium inoculation and the use of fertilzers). In a test of whether or not the male extension staff could work with women farmers, the WIADP held demonstrations one year and gave inputs and instruction to 59 female cooperators. There were a range of environments and it was possible to compare the performance of women farmers. The better farmers had better management and viable inoculum. The poorer farmers had

problems with pests and unviable inoculum because they failed to reinoculate after late rains and delayed planting. As a result of the demonstrations and surveys of both men and women farmers involved in soybean production in a number of areas, the problem of how to get viable inoculum to the rural areas was identified as a general problem affecting both men and women. In addition, there were gender specific smallholder problems such as the lack of training and the limited seed given to women. Trials were held the following year with 20 female cooperators selected by the male extension staff. In addition to trying to solve the technical problems, two other questions were asked. Could women do on-farm research with precision? Could the male extension staff work with women and what were the methods that worked best? The answers to both of the questions were affirmative. The women were able to learn the procedures for the trials with precision. Special techniques were used to instruct them and to test their knowldege of the techniques before they planted their trials. Second, the male extension staff had no difficulty in identifying and instructing the women as well as in monitoring the trials (Spring, 1986b).

To capitalize on the discovery that women could be part of trials, participate in extension services, and that the male staff could work with women (in terms of instruction, visits, monitoring crops, etc.), the WIADP prepared an extension circular. The circular was unique in that it was issued by the Ministry of Agriculture rather than by the WIADP. Extension circulars from the MOA are regarded as technical recommendations to be distributed to the entire extension staff and to be heeded by them. Although the general policy for the delivery of extension services is "nondiscriminatory", the data showed that women were not being contacted as too few received credit and other services. There was need to legitimize the fact that male extensionists all over the country could work with women as well as with men farmers in their areas and that working with women farmers was not only the concern of the few female extensionists (who consisted of 150 out of 1950 extension workers). The circular was entitled "Reaching Female Farmers Through Male Extension Workers" and was published in August 1983 (MOA, 1983). An article in the national newpaper marked its distribution to all grass roots workers and to agricultural project management. The circular drew attention to the fact that extension services need to reach women because of women's involvement in Malawi's smallholder agricultural sector. It stated that some people might want to argue that women are interested in home economics rather than in agricultural training that has mostly been directed to men. It pointed out that where women have been offered agricultural programs, they have learned new technologies and increased their production. The circular used photographs taken from the MOA's own collection and depicted women in various farming operations, attending extension demonstrations led by male extensionists, attending village meetings with male farmers, receiving credit inputs along with men, and exhibiting a certificate of recognition for excellence in farming.

The circular presented methods for improving the delivery of extension services to women and for getting women into extension and research activities. Techniques were given on how to encourage women to attend village meetings and agricultural training courses, and how to increase women's participation in credit programs and farmers' clubs. The male extensionists were directed to include women at their demonstrations, trials, and field days. They were also told to keep records of contacts and program involvement in terms of the number of women and men participating. Detailed suggestions

were offered for recruiting women farmers, the use of leadership training so that women might learn to express their problems, and techniques to increase participation in credit and soil conservation programs. It was noted that there are a variety of household types and that women both as wives and as heads of households need to be targeted.

Prior to the circular, some male extensionists included women farmers in their programs, but in general, the inclusion of women was neither consistent nor reflective of women's contributions and needs in an area. Most male extensionists believed that women farmers were to be contacted by female extension workers and that rural women only should study home economics. The Circular legitimized and mandated that male extensionists work with women farmers in the smallholder sector.

These techniques might not work in every corner of the world, but the general argument that says that men cannot work with women farmers needs to be reexamined. New methods and techniques have to be devised that are feasible and that consider cultural traditions. In addition, female extensionists must not be left out. The number being trained in agricultural subjects must be increased. In the case here, female extensionists subsequently were taught how to cultivate and innoculate soybeans. Incentives and promotions are also necessary for them. In addition, the curriculum of the home economics courses for rural women must be modified to include materials that are directly related to women's productive roles.

CONCLUSIONS

Those involved in FSR/E must be prepared to keep their eyes open at all stages of the work. In the prediagnostic stage they must consider primary and secondary sources that detail the sexual division of labor and the changing roles of various household members. Sometimes this type of information is available, other times it must be collected in the field. An example of a focus on women's roles in crop production was prepared for a commodity oriented project. The Bean/Cowpea Collaborative Research Support Program, funded by USAID, specifically developed resource guides for a number of African and Latin American countries. These guides detail women's roles in agriculture and the ways that breeders and other production scientists can make use of this information (Fergusen and Horne, 1985). Where this type of information is not readily available, researchers may have to disaggregate agricultural data sets in order to ascertain gender differences or to collect their own data from local women and men farmers.

In the practice of FSR/E, researchers must confront extension workers with the need to include in their surveys a diversity of farmers in terms of resources, household and family types, and to consider people at different points of their life cycle in the diagnostic stage. Strict instructions need to be given to extension personnel for them to include in their surveys: a) low as well as high resource farmers, b) women farmers with both low and high resources, and c) women as both household heads and wives. The sexual division of labor and differential management strategies will have to be discerned. If questions on the allocation of labor and resources, problems and needs, remuneration, and investments cannot be answered for different categories of farmers, the work is incomplete. If only men provide the answers about women, the data are most likely biased.

In the design of trials, intrahousehold dynamics and the needs of various household members must be considered; a range of farmers and of environments need to be included. In the actual trials, women as well as men have to participate as cooperators. In some trials it may be necessary to restrict the cooperators to the sex that actually is responsible for a particular commodity, e.g., groundnuts are often a women's crop in some areas. In others, recognition of the fact that women and men do different farm operations means that both male and female household members will have to be considered as trial participants and that both will have to be instructed accordingly. The extension and research workers who will help select and monitor the trials will require strict instructions as to how to choose and to work with these farmers. Researchers should not be fearful about including a range of environments, but they need to be careful about selecting too many farmers in certain categories and in comparing farmers at different resource levels. Recommendation domains and technologies tested may or may not be gender specific.

In the dissemination of information, the male research and extension staff members will be important to the success of adopting a technology. The WIADP recognized that it was often difficult for individual extension and research workers on their own to make special attempts to deal with neglected segments (such as women) of the population. Usually the FSR/E personnel will have the clout to influence policy and sometimes to provide motivation and incentives for new directions. FSR/E personnel can therefore attempt to set the tone and to require that women as well as men be targeted. They can assist extension workers in discovering the techniques that will work in an area.

The only way to ascertain if these steps have been followed is to monitor the various phases in the practice of FSR/E and to disaggregate the data by sex. This means that the target farmers and the data generated from them will have to be specified in terms of males and females. The notion that technology is gender neutral will have to be examined in terms of who the recipients are as well as the consequences of the technology to the household and to its constituent members.

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TABLE 1: MALE AND FEMALE EXTENSION PERSONNEL IN AGRICULTURAL PROGRAMS: AFRICA, ASIA AND THE PACIFIC, LATIN AMERICA AND THE CARIBBEAN, AND THE MIDDLE EAST

AFRICA	Agriculture		Home Economics		Other		Total		% Female
	M	F	M	F	M	F	M	F	
Botswana	186	13		2	178	9	364	24	6
Gabon	80	-	-	-	11	2	91	2	2
Gambia	170	6	-	-	457	9	627	15	2
Mauritius	56	-	-	-	18	2	74	2	3
Nambibia	11	4	-	-	8	-	20	4	17
Nigeria	1106	104	-	-	680	9	1786	113	6
Senegal	1088	3	-	1	71	-	1159	4	3
Seychelles	11	3	-	-	3	1	14	4	22
South Africa	1107	-	-	2	563	-	1670	2	0
Togo	-	-	-	-	212	-	212	-	0
Tunisia	-	-	-	-	12	3	12	3	20
Zimbabwe	1682	23	-	-	551	72	2233	95	4

ASIA AND THE PACIFIC	Agriculture		Home Economics		Other		Total		% Female
	M	F	M	F	M	F	M	F	
American Samoa	4	-	-	-	10	-	14	-	0
Korea	4651	-	2	342	2647	6	7300	348	5
Malaysia	2612	383	-	384	1141	105	3753	872	19
Maldives	6	-	-	-	3	3	9	3	25
Nepal	5000	-	-	-	132	17	5132	17	0
New Caledonia	36	-	-	1	69	20	105	21	17
Philippines	6767	3642	-	1270	4639	2702	11406	7614	40
Thailand	3672	936	27	765	2002	84	5701	1785	24
Tonga	23	-	-	9	44	1	67	10	13
Vanuatu	44	-	-	-	5	-	49	-	0

LATIN AMERICA AND THE CARIBBEAN	Agriculture		Home Economics		Other		Total		% Female
	M	F	M	F	M	F	M	F	
Belize	35	-	-	-	13	-	48	-	0
Bermuda	5	-	-	-	6	-	11	-	0
Bolivia	122	-	-	-	36	-	158	-	0
Costa Rica	57	-	-	45	168	40	225	85	27
El Salvador	128	-	-	76	215	61	343	137	29
Grenada	27	8	-	-	32	2	59	10	15
Guadeloupe	-	-	-	-	57	1	57	1	2
Guatemala	254	-	-	64	288	-	542	64	11
Honduras	180	2	-	53	156	8	336	63	16
St. Kitts, Anguilla, Nevis, St. Vincent	31	3	-	1	10	1	41	5	11
Trinidad & Tobago	118	7	-	-	19	3	137	10	7
Uruguay	33	5	-	-	148	25	181	30	14

Source: Berger, Marguerite et al. Bridging the Gender Gap in Agricultural Extension. International Center for Research on Women, Washington, D.C., 1984.

TABLE 2: AGRICULTURAL TRAINING INSTITUTIONS IN MALAWI
NUMBER OF GRADUATES AT BUNDA COLLEGE OF AGRICULTURE (DEGREE, DIPLOMA), COLBY COLLEGE OF AGRICULTURE AND THUCHILA FARM INSTITUTE (FARM HOME ASSISTANTS) BY YEAR AND SEX

	Bunda				Colby		Thuchila*
	Degree (5 yr)		Diploma (3 yr)		(2 yr)		(1 yr)
	Male	Female	Male	Female	Male	Female	Female
TOTAL	273	24	797	124	2255	45	291
% Female	8%		13%		2%		Average/yr 22

* Course for Female Only

TABLE 3: TRAINING FOR EXTENSION AGENTS IN NEPAL 1983-84*

Duration of Course	Males Enrolled	Females Enrolled	Percent Female
3 years	73	0	0.0
	84	2	2.3
	150	1	0.7
2 years	248	2	0.8
	196	2	1.0
	170	0	0.0
1 year	216	1	0.5
	172	3	1.7
1 month	25	0	0.0
	200	0	0.0
	-	28	100.0
TOTAL	1534	39	2.5

* Source: After Shrestha, Padma et al. Planning Extension for Farm Women, Integrated Cereals Project, USAID Kathmandu, Nepal, 1984, p. 64.

TABLE 4: PERCEPTION OF FEMALE CONTRIBUTION TO ON-FARM WORK AND DECISION-MAKING (PERCENTAGE OF RESPONDENTS WHO SAID WOMEN'S CONTRIBUTION TO WORK/DECISION-MAKING IS MORE THAN THAT OF MALE'S)

Women's Contribution to	Female Farmers		Extension Agents				Status of Women Report
	Hill Area	Terai Area	Female AA	Male AA	JT/JTA	ADO	
Work	78	80	72	26	56	22	67
Decision-making	31	38	52	20	0	0	42

Source: Shrestha, Padma et al. Planning Extension for Farm Women, Integrated Cereals Project, USAID Kathmandu, Nepal, 1984, p. 29.

TABLE 5: CONTACTS BY EXTENSION AGENTS PER MONTH REPORTED BY FEMALE FARMERS IN NEPAL (FREQUENCIES AND PERCENTAGES)*

Type of Extension Agent	Area 1 Dang	2 Parsa	3 Lamjung	4 Dhankuta	Total
Male JT/JTA[b]	21	26	8	8	63 (58%)
Male AA[a]	1	23	2	2	28 (26%)
Female JT/JTA	1	-	-	-	1 (1%)
Female AA	16	-	-	-	16 (15%)
TOTAL	39 (36%)	49 46%)	10 (9%)	10 (9%)	108 (100%)

TABLE 6: MOBILITY OF FEMALE FARMERS VS. SEX OF EXTENSION AGENT BY DISTRICT IN NEPAL (PERCENTAGE OF WOMEN IN EACH CATEGORY RESPONDING AS SUCH)*

	Area 1 Dang	2 Parsa	3 Lamjung	4 Dhankuta	Total
Would go to a male extension agent	8	20	50	33	29
Would talk to a male extension agent in home	18	35	75	50	46
Would go to a female extension agent	94	90	92	94	93
Would talk to a female extension agent in home	100	100	97	100	99

*Source: Shrestha, Padma et al. Planning Extension for Farm Women, Integrated Cereals Project, USAID Kathmandu, Nepal, 1984, p. 31 & 52.

TABLE 7: TYPE OF EXTENSION CONTACTS FOR MALE HOUSEHOLD HEADS (MHH), FEMALE HOUSEHOLD HEADS (FHH), AND WIVES FROM THE NSSA EXTENSION SURVEY, MALAWI (PERCENTAGES) 1980-81**

TYPE OF CONTACT	Lilongwe			Ngabu			Karonga	
	MHH (n=147)	WIVES (n=35)	FHH (n=35)	MHH (n=95)	WIVES (n=95)	FHH (n=31)	MEN (n=70)	WOMEN* (n=73)
Personal Visit	41	28	23	28	12	4	44	29
Group Meeting	66	44	49	43	12	8	61	34
Demonstration	13	6	6	5	1	0	16	10
Field Visit	13	9	6	15	5	2	16	4

*Female household Heads and Wives were tabulated together (Women) and compared with the Men.

** Source: Spring et al. Women Farmers in Malawi: Their Contribution to Agriculture and Participation in Development Projects, Women in Development Office, USAID and Ministry of Agriculture, Lilongwe, Malawi, 1983.

TABLE 8: MAIZE YIELD FROM FARMER-MANAGED, ON-FARM TRIALS, PHALOMBE, MALAWI, 1981/1982

Treatments	Farmers in first village								Treatment Mean for Village
	1	2	3	4*	5	6*	7*	8	
	t/ha								
Local Maize	2.2	2.2	1.9	1.2	1.3	0.9	1.0	0.5	1.4
Local Maize Fertilizer	3.6	3.7	4.3	3.2	2.3	2.3	3.1	2.8	3.2
Composite	3.5	2.0	2.9	0.4	0.6	0.5	0.6	0.3	1.3
Composite Fertilizer	5.0	4.7	4.3	3.5	2.4	1.7	3.0	2.8	3.4
Mean for Farmer	3.6	3.2	3.3	2.1	1.7	1.3	1.9	1.6	

	Farmers in second village						
	1	2	3	4*	5*	6*	
Local Maize	1.8	1.1	1.6	1.0	1.6	0.6	1.3
Local Maize Fertilizer	3.2	2.5	2.9	1.2	1.9	0.8	2.1
Composite	2.2	0.7	0.9	0.3	1.1	0.3	0.9
Composite Fertilizer	2.9	2.5	2.1	1.1	0.8	0.4	1.6
Mean for Farmer	2.5	1.7	1.9	0.9	1.4	0.5	

Data from Hansen 1985 * Female Farmer

Source: Hildebrand and Poey (1985) On-Farm Agronomic Trials in Farming Systems Research and Extension. Lynne Rienner Publishers: Boulder, Colorado, p.

TABLE 9a: GRAIN YIELD RESPONSE FOR LOCAL MAIZE (L) AND CCA COMPOSITE (C) TO ENVIRONMENT, WITHOUT FERTILIZER. PHALOMBE PROJECT, MALAWI*

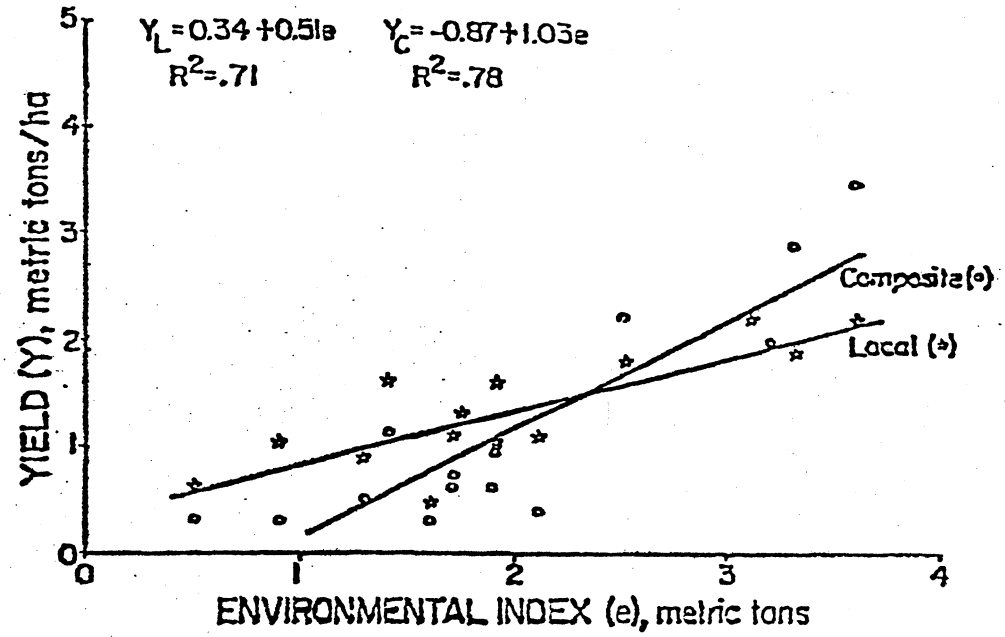
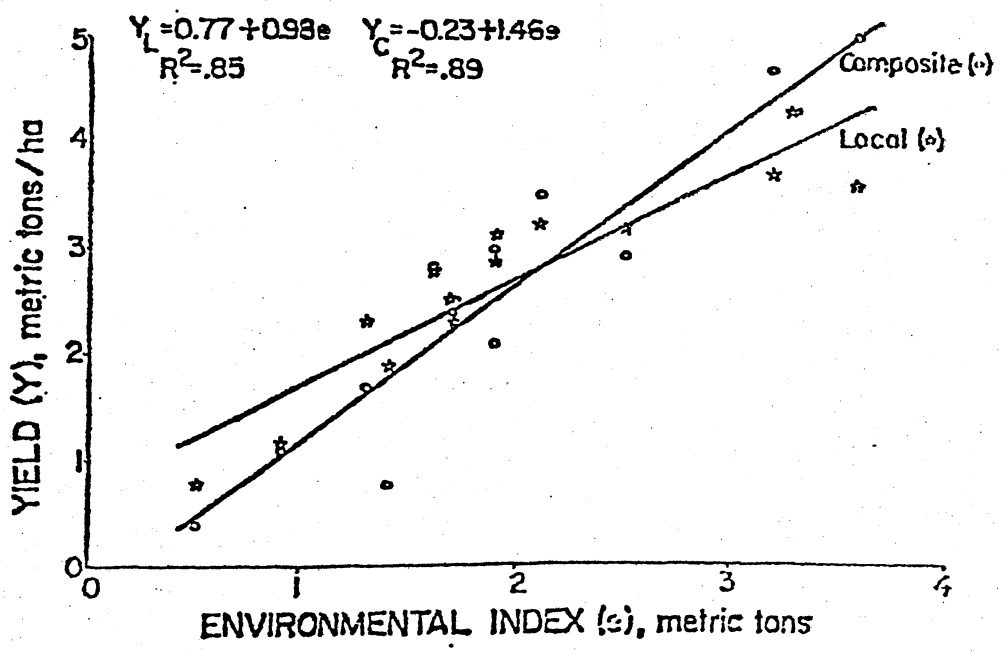


TABLE 9b: RESPONSE OF LOCAL MAIZE (L) AND CCA COMPOSITE (C) TO ENVIRONMENT, WITH FERTILIZER, PHALOMBE PROJECT, MALAWI*



* Source: Hildebrand, Peter E. and Federico Poey, On-Farm Agronomic Trials in Farming Systems Research and Extension, Lynne Rienner Publishers: Boulder, Colorado, pp. 129 - 130.

TABLE 10a: DISTRIBUTION OF CONFIDENCE INTERVALS FOR GRAIN YIELD OF LOCAL AND CCA COMPOSITE MAIZE, PHALOMBE PROJECT, MALAWI. HIGH ENVIRONMENTS - FIVE FARMS WHERE AVERAGE YIELD (Y) GREATER THAN 2t/ha*

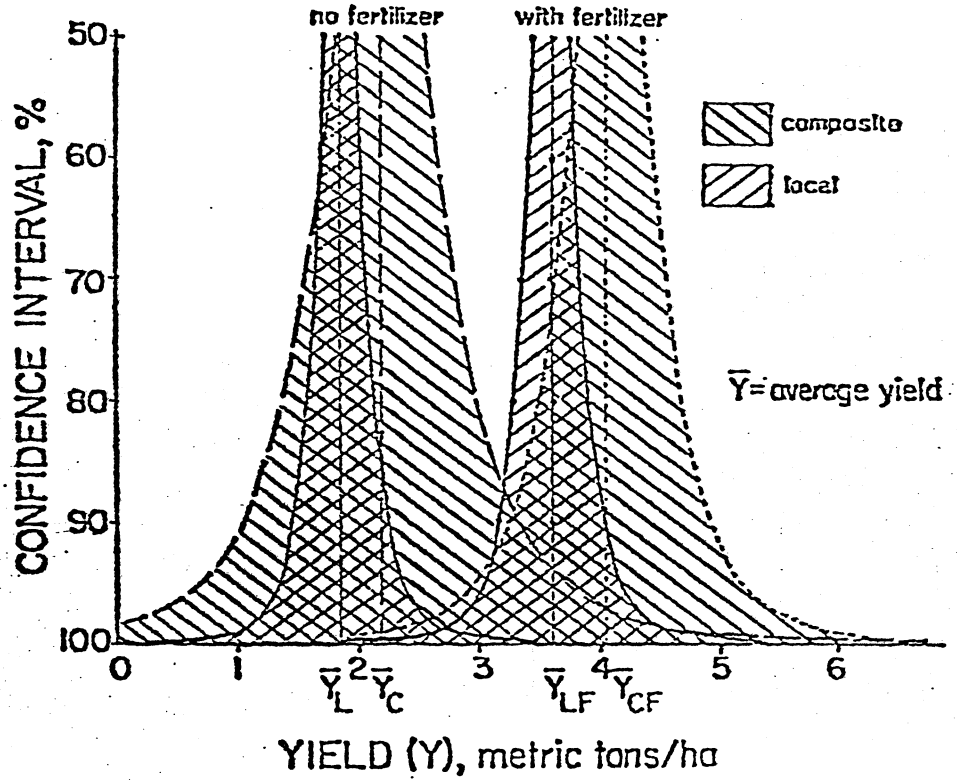
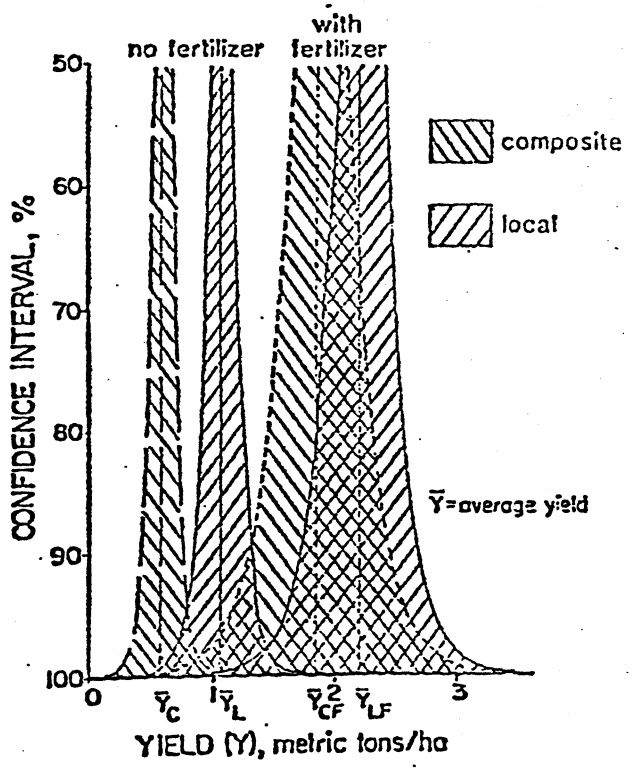


TABLE 10b: DISTRIBUTION OF CONFIDENCE INTERVALS FOR GRAIN YIELD OF LOCAL AND CCA COMPOSITE MAIZE, PHALOMBE PROJECT, MALAWI. LOW ENVIRONMENTS - NINE FARMS WHERE AVERAGE YIELD (Y) LESS THAN 2t/ha *



*Source: Hildebrand, Peter E. and Federico Poey, On Farm Agronomic Trials in Farming Systems Research and Extension. Lynne Rienner Publishers: Boulder, Colorado, pp. 133-134.

POTENTIAL OF FSR/E FOR SMALL FARMS IN DEVELOPED ECONOMIES

Wesley N. Musser, Stanley F. Miller, David G. Acker

Farming Systems Research and Extension (FSR/E) was conceived and is being applied to organize agricultural research and extension programs for small farms in developing economies. Small farms are also an important component of the agricultural production system in many developed economies. These small farms are often larger in terms of output or input usage than in developing countries. In addition, the consumption of these farm families are usually not at the subsistence level of developing countries. On the other hand, these two types of small farms have some similarities: (1) standard technologies for commercial farms are often not appropriate for the resource availabilities and/or consumption-production interfaces of small farms, and (2) resources are limited and cannot be supplemented with market transactions. These characteristics have been integral premises of FSR/E in developing economies. In contrast, concepts of small farm problems in past and current policies, at least in the United States, emphasize assisting small farmers to become commercial farmers and ignore these principles of FSR/E.

This paper has the purpose of explaining the potential of FSR/E for small farms in developed countries. Consistent with the exploratory nature of the paper, much of the content is suppositions or working hypotheses for further reflection and research. Literature reviewed in this paper is limited to the United States situation and views expressed in the agricultural economics literature which reflect the experience of two of the authors. However, these views probably have wider professional and geographical relevance. With these caveats, the paper has several major parts. The first section reviews historical and current concepts of research on small farms in the United States. The second section outlines relevant FSR/E concepts as a critique of these traditional concepts. The third section discusses the relevance of FSR/E for different forms of small farms in the United States; this section discusses possible taxonomies of the heterogeneous group. The final section concludes with some general conclusions about FSR/E in the land grand college system.

Agricultural Economics Perspectives on Small Farms in the United States

Small farms have had an important role in public policy throughout the history of the United States. The Jeffersonian tradition of the importance of small farms had a profound influence on U.S. federal land policy, the establishment of the land grant system, and the Farm Credit System. These public policies all contributed to the transformation of a largely subsistence agriculture into the modern commercial sector. This tradition has, of course, influenced agricultural economics, especially in its beginnings (Ely and Wehrwein). Not until the 1930s did a public awareness emerge that a large component of small farmers was not participating in the transformation into commercial farms. As the modern discipline of agricultural economics was emerging at the same time, concepts expressed in this literature can be used to document concepts and programs for small farmers.

In a major review of farm programs in 1956, Benedict summarized the situation for small farmers at that point as follows:

> The depression of the 1930s, and the devastating droughts of that period, focused attention on a number of agricultural problems that had been almost unrecognized up to that time. Among them was situation of the chronically impoverished small farmer who lived at a bare subsistence level even in ordinary times.
>
> Farmers of this kind had shown great powers of survival in most depression periods. They produced little for the market and bought little. However, they had for some generations been falling farther and farther behind the more progressive farmers in their standards of living and levels of income. Until the 1930s neither the farm organization nor the Congress gave much attention to this problem. Most of the low-income troubles did not stem from some sudden, highly publicized catastrophe such as a drought or flood which would be likely to arouse congressional interest (pp 182-3).

The large number of small farmers and their economic and social plight in the 1930s did stimulate a federal policy response. The Resettlement Administration, which later became the Farm Security Administration and even later became the Farmers Home Administration, was established to assist small farmers. The programs of this agency had a dual role: (1) credit to acquire land and other resources, and (2) management assistance in adoption and use of modern agricultural technologies. Benedict described the program as follows:

> The rural rehabilitation loan program constituted the most significant change in lending practice and general philosophy. It was an approach designed to bring about a positive and guided change rather than merely to preserve existing farm structure and methods of operations. .....and has apparently become a rather settled feature of the farm program.
>
> The first step in making a loan of this kind is the preparation of a plan for increasing the productivity, income and level of living of a farm family whose financial status is such that it cannot borrow through ordinary credit channels. Such a plan may call for increased use of fertilizer, more or better livestock, a change in kind of product, enlargement of the farm, the use of more machinery or some combination of these. For some families, the need is for more productive land resources to be acquired either through rental or purchase.
>
> These changes usually require both additional capital and guidance in the effective use of borrowed funds. The fact that loans can be made for carrying out such improvements provides a powerful incentive for accepting the guidance that goes with them. The later supervision not only helps to bring about the improvements agreed on but makes it more likely that the loans will be repaid when due (p 186).

Interestingly enough, the agency had the same mission as early agricultural public institutions; however, it was explicitly focused to

small farmers. The issue of why these forms of public programs had not been successful was not explicitly considered. Benedict argued that these farmers needed a "... different kind of service which is especially suited to the needs of this group" (p 188). However, other than consolidation of programs from different agencies limited content changes occurred. Perhaps, an examination of the appropriateness of services would not have been popular with traditional institutions and their commercial farm clientele. The implicit policy rationale seemed to be a question of clientele -- the small farm problem reflected neglect rather than inappropriate program content. Not surprisingly established institutions recognized this implicit policy view and had the political power, represented in the farm bloc, to constrain these limited policy efforts (McConnell).

The similar program content with established programs was consistent with the overall goal of these programs. The policy goal was to assist these farmers to become part of the commercial system. Economists accepted and/or articulated the overall goal and the existing program content. In fact, it almost become dogma. In the most influential agricultural economics book of the 1950s, Heady endorsed the Farmers Home Administration program:

> The public itself should carry these risks in the form of low equity loans. A loan program of this nature need not entail great credit risks if integrated with extended education and provision of management assistance to aid in the selection of crops, livestock, and technical production methods. The need for a farm enlargement program is so great that material progress can be made only if the efforts of educational institutions and private and public credit agencies are integrated and intensified. It has been estimated that productivity per worker can be increased more on small farms by improving the organization of resources than by extending the scale of the unit (p. 760).

In the 1950s, an important transition in concepts of programs for small farms emerged. While support for earlier programs continued, the impossibility of all small farmers becoming commercial farmers was recognized. All existing farms becoming larger was impossible due to limited land resources and/or markets for increased production. Heady recognized this fact - "Widespread accomplishment in expansion of farm size would necessitate the transfer of many individuals from agriculture" (p. 760). He then endorsed a set of education and manpower programs to accomplish this transfer process (pp. 760-2). This later view became the new dogma of agricultural economists with much research devoted to this issue with limited fruitful outcomes (Fuller). This new view of small farmers did shift intellectual concepts, at least, away from the older dogma of assisting them to become commercial farmers. Standard agricultural policy texts recognized that these small farms would never have their low income status improved in agriculture (Hathaway; Paarlberg). During this era, a combination of migration and rural industrialization resulted in a significant drop in numbers of these small farmers.

The goals and programs of the 1930s had an amazing resiliency both in public policy and among agricultural economists. The Economic Opportunity Act of 1964, which was the formal authorization of the War on Poverty,

contained a renewed program of supervised grants and credits for small farms (Levitan). The Rural Development Act of 1972 also contained special provisions for research and extension for small farmers with similar programs. This renewed policy thrust has led to a recent detailed examination of the small farm situation. West; Carlin and Crecink; Tweeten, Cilley, and Popoola; and Ghebremedhin and Johnson gave invited papers at recent professional meetings, which provide extensive literature reviews. An important issue in many of these papers concern definition of the small farm population in the United States; the heterogeneity of this population is stressed, which is an innovation over earlier literature. However, the perennial issue of research and extension programs for these farmers is also an important component of these papers. The New Deal theme of targeting existing programs for this group is still apparent. Tweeten, Cilley and Popoola argue that existing programs can serve the needs of at least a component of this population and Ghebremedhin and Johnson argue strongly for special funding for black land grant institutions for these problems. However, some awareness of the need for fundamental reorientation are apparent. In perhaps the most insightful paper of the group, West argues that most agricultural technology is not appropriate for small farms, they have limited access to existing markets, modern input markets penalize small farmers, and many government policies favor larger farms. He calls for explicit development of technology for small farms, more attention to markets for small farmers, and explicit attention to goals and objective of small farmers. Ghebremedhin and Johnson also mention these issues and endorse interdisciplinary research on these issues. Many of these breaks with traditional views sound similar to FSR/E concepts. However, no linkages with FSR/E literature is apparent in this literature. The next section of this paper turns to this issue.

Elements of FSR/E - Relevance for Developed Economies

The literature on FSR/E is becoming quite extensive and a review and contrast of differences in emerging concepts is beyond the scope of this paper. The recent paper of Byerlee, Harrington, and Winkelmann is used in this section to outline elements.

These authors note the following elements in developing economies which create a complex system: (1) a long growing season with wide range of crops and potential of multiple cropping, (2) unreliable input and output markets, (3) family consumption of own production, (4) family labor is an important input, and (5) resources are heterogeneous (p. 898). While the long growing season is not characteristic of all of the United States, it certainly has relevance for the South and the Pacific Far West. The first of these regions has historically accounted for many of the small farmers. Tweeten, Cilley, and Popoola report that 41.19% of the small farms were in the South and 4.62 percent in the Pacific areas in 1974; the East North Central region, which has many cropping alternatives but not as long of growing season, accounted for 20.89 percent of the farms (p. 82). Thus, the element of complexity is also existent in many areas of the United States. Characteristics of labor and land resources is also readily apparent to have relevance. Problems with input and output markets for small farmers in the United States were noted in the previous section; admittedly, these problems are of a different nature than in developing countries but still constrain production. Finally, production for home consumption is also of less

relevance than in many developing economies. While the authors found no evidence in the literature on this issue, it is plausible that a larger percent of home consumption occurs than for commercial farms. An additional difference is the existence of a public welfare safety net to guarantee subsistence in developed economies, which may allow small farmers to accept more risk and be more conducive to change. Overall, the situation for small farmers may not be as complex a system as in developing economies but the elements all seem to be relevant.

As a research and extension approach, FSR/E has several important components, which contrast with the traditional Land Grant approach:

(1) Research is planned on a multidisciplinary rather than a disciplinary basis.

(2) Interaction with farmers and an understanding of their complex system is important in addition to scientific interest.

(3) Multiple goals and limiting resources of farm families are considered rather than increasing output or profits alone.

(4) Experiments are conducted at the farm level with active farmer involvement rather than at the experiment station.

and,

(5) Technical change in, farming systems is considered rather than single enterprises.

Again, all authors would not necessarily agree with this list but it does capture some important contrasts with traditional land grant organization.

To evaluate the potential of this methodology for small farmers in developed economies, it is important to review why the land grant system has been effective for commercial farmers. By the very definition, commercial, farmers are intimately involved in markets for production inputs and outputs and consumption goods. Thus, resource limitations are not effective constraints at least over time. Furthermore, they have sufficient resources that specialization is possible. As a result, overall efficiency or technical superiority of practices for particular enterprises can be considered in an incremental fashion ignoring the whole system. With experience in innovation, they can adopt results of scientific trials to their own production system on a piece meal basis. Of course, these farmers also have multiple goals (Patrick and Kliebenstein); however, profit calculations are a component of these goals and access to resource markets can alleviate the effects on other goals.

As the literature recently recognizes, the traditional land grant system has not worked for small farmers. It is an interesting hypothesis that the lack of commercialization of small farmers is the reason for this failure. Such a hypothesis warrants further attention. Since FSR/E breaks with this tradition, it is also a plausible hypothesis that this approach could be used to develop technology useful for small farmers. The systems approach combined with active interaction with farmers in the planning,

implementation, and evaluation of research should facilitate some progress on production conditions for small farmers. The break with tradition could create both instructional and productivity problems for colleges of agriculture. These issues will be discussed in the concluding section. First, the next section considers the issue of heterogeneity of small farms. Using the general hypothesis of resource limitations as an overall characteristic of small farmers, salient characteristics of population components are used to deduce general needs of these components.

Population Components and Production Limits

Small farms in the United States are very heterogeneous. Social scientists have recognized this issue and have attempted to derive general classification schemes to address these issues. Much of the empirical work has been with aggregate national data, which does have limitations. Tweeten, Cilley, and Popoola proposed a three way classification: (1) part-time, where the operator works 200 or more days per year off the farm, (2) aged, where the operator is 65 years or older, and (3) bona-fide, which is the residual full time active small farmers. Defining small farms as units with sales greater than $2,500 but less than $20,000, they classified 278,650, 200,539, and 409,521 farms in these respective categories in 1974. More recently, concepts of small farmers related to low levels of economic well being and/or farm income being a significance of family income have also been suggested (Carlin and Crecink; Ghebremedhin and Johnson). While these definitions probably have relevance for some policy purposes and do correspond with traditional concepts, they eliminate many small farmers from consideration, particular in part-time and aged categories. Furthermore, poverty status can arise from many factors unrelated to farming system. Voth, Halbrook, Chapman, and Renfro found that the above three-way categorization resulted in much more homogenous categories than did poverty status.

This three-way classification actually seems fairly robust. Using cluster analysis of survey data from Oregon, Young and Caday found four categories. Aged and part-time were two of the categories; bona-fide was broken into a group using conventional commercial technology and a group using alternative technology emphasizing no chemicals and limited machinery. Many farmers in this later group are small and use this technology because of preferences rather than resource constraints. In a later similar study, Young pooled data from five Western states and derived ten categories. In a sample of 193 farms, the bona-fide, conventional technology group had 52 cases and was the most distinct. The other nine groups was distinguished by alternative technology and included two aged categories, three part-time categories, and four bona-fide categories. Thus, the distinction between type of technology seems to be an additional distinguishing characteristic. This study also definitely supports the FSR/E concepts that distinct homogeneous groups could be delineated from surveys, even in overview surveys.

The general FSR/E principle of resource limitations can be used to deduce some hypotheses about relevant production problems for these components. West noted that lumpy capital investments and access to input and output markets were primary problems of small farmers. The bona-fide conventional farmers seem to especially have these problems. Emphasis on

fixed capital with less cost disadvantages for small scale farmers is the most apparent technological need of this group; substitution of labor for capital in this technology would also seem relevant. Engineering research and production practices research which do not require large machinery or other capital investments, also would be consistent with the resource endorsements of this group. The traditional emphasis on additional financing and education on commercial practices also is consistent with this group. The traditional view of intensive livestock and horticultural enterprises also seems appropriate for the resources of this group.

Emphasis on smaller fixed capital items would be appropriate for many of the other groups. However, the preferences for non-chemical production practices is a relevant aspect of production systems of these groups. Horne has noted that small tractors and other farm machinery from an earlier era could be appropriate and have less cost disadvantages for small farmers. This principle may hold for production practices. Rotations, diversified livestock-crop enterprises, and non-chemical pest control methods may be sources from earlier eras of technology for further refinement consistent with preferences and/or financial capital limitations of these groups of small farmers.

Enterprise selection must be consistent with the alternative production methods and would vary among these other groups. For all these groups, enterprises with severe pest problems are not a good alternative -- cotton in the South is one salient example. The bona-fide, alternative technology farmers do have the labor resources for labor intensive enterprises -- livestock and horticultural enterprises without severe pest problems may be logical choices for these groups of they have the management resources. Part-time farmers have severely limited labor and management resources; some with off-farm income and investments may be less constrained by financial capital. Forestry, beef cattle, integrated poultry operations and field crops are traditional enterprises for at least components of this group. Systems models, including those in agricultural economics, should not consider management-intensive enterprises such as hogs and horticultural crops for the part-time group. General hypothesis for the aged group are not as apparent -- new enterprises with a long planning horizon such as tree crops would seem not as appropriate. More detailed empirical studies of the aged group seem to be necessary.

The FSR/E concept of identifying homogeneous groups and defining priorities different from conventional commercial technology appears to be relevant for different components of small farmers. The analysis in this section also suggest that economic reasoning is useful to derive hypothesis concerning relevant production issues. Such an approach should be useful in specifying components of the system important to more fully specify with the FSR/E empirical analysis. In addition, it reduces the pure empiricist focus of FSR/E, which is distasteful to many modern agricultural economists and perhaps other scientists.

FSR/E in the U.S. Land Grant System

This paper suggests that FSR/E has the potential to be a fruitful approach for increasing involvement of the land grant system for small farmers in the United States. Such an emphasis has both benefits and costs

for the land grant system. As Crecink has recently argued, the value of small farms to society cannot be easily rationalized, but society does value this group. If FSR/E programs bear out their promise for small farmers, the political embarrassment of lack of commitment to this population component would be eliminated. This commitment is especially important if the perceived trend of decline of mid-sized farms continues (Knutson). These farms have been the traditional clientele of the land grant system for which considerable public support exists because of their largely family farm organization. Large farms would have neither the need for the current system nor generate the sympathetic public support and resources for the existing system. Furthermore, a domestic FSR/E program would be complementary with an international commitment to this effort and could be used to justify use of public revenues for international programs.

Despite the potential of a domestic FSR/E program, implementation of such a program will create stress for the land grant system. As argued above, the land grant system is based on specialization, decentralized decision making within disciplines and among scientists, and research at central stations. Adoption of an FSR/E approach could create stress from institutional change; for example, academic freedom may be reduced. Furthermore, such an approach may not be as productive in generating technological change for these farmers as the current system has been for commercial farmers. The time commitments to farmers plus the coordination of interdisciplinary research projects creates overhead which will reduce research. Furthermore, scientific progress undoubtedly follows Adam Smith's principles that specialization and decentralized decision-making is most efficient in terms of total output despite the philosophy of systems analysis.

One approach that may reduce the sharp break with the land grant tradition is not to insist that all small farm efforts be forced into the "pure" FSR/E approach including surveys, system analysis, and farmer trials. Rather, a large component could be maintained in experiment stations with an increased emphasis on production methods with small farm resource limits in mind. Some of the hypothesis in the previous section are examples. Improving small scale machinery and animal facilities and non-chemical production methods could be subjected to the same scientific standards and be complementary with more purist FSR/E effort. Definitely a major FSR/E approach would require flexibility both from FSR/E theoreticians and traditional land grant college personnel.

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MANAGEMENT AND THE FSR/E TEAM

Federico Poey

Donald L. Esslinger and Constance M. McCorkle

THE BI-LEVEL FSR/E TEAM; FUNCTION COMPOSITION AND IMPLEMENTATION

Federico Poey, AGRIDEC

The execution of a Farming Systems approach to research and extension depends on the planning and realization of field activities that integrate related disciplines. These activities require follow-up during the implementation process both at the experiment station and in the farmers' fields. The integration also needs to be of a permanent nature, currently up dated and related to other collaborative institutions. It is evident and generally accepted that multidisciplinary teams need to be organized and specific responsiblities need to be assigned. However, the function, composition, and implementation of these teams represents a major undertaking, particularly when the Farming Systems Research and Extension approach (FSR/E) is to be incorporated into traditional institutions, organized by disciplines or commodities, and when research is separate from extension.

Some of the limitations and constraints to the introduction of the FSR/E approach commonly found are:

1. Non receptive leadership.
2. Fixed budget allocation.
3. Centralized management.
4. Strong discipline/commodity specialization.
5. Discipline/commodity program objectives.
6. Lack of integrating mechanisms.
7. Inadequate human and physical resources.

Any attempt to organize FSR/E multidisciplinary teams needs to be considered within this framework of limitations. This means that each case has to be adapted and implemented differently, making adjustments and approximations to an ideal or theorethical structure.

Some efforts made to organize FSR/E multidisciplinary teams in the last few years in many countries have resulted in questionable effectiveness. Some consequences of these efforts have been:

1. Personnel and institutional friction.
2. Top down implementation of FSR/E activities.
3. Minimal use of resources available.
4. Imbalance of multidisciplinary action.
5. Improper application and/or conceptualization of the FSR/E approach.
6. Lack of impact in the farmers' communities.

A better understanding of the functions, composition, and implementation mechanisms of the FSR/E team structures could contribute to an effective applications of the FSR/E approach.

Functions

The following functions should be considered:

1. Organizational

There are two levels where multidisciplinarity is necessary within a FSR/E team structure. One is at the decision makers' hierarchical level and the other is at the field, physical implementation level. The two levels should be properly integrated in their functions as to achieve the most effective utilization of resource available while maintaining the premises of the FSR/E bottom-up approach, strong researcher-farmer-extentionist interaction, and high numbers of on-farm trials. This function implies a FSR/E team structure that allows for a multiplication effect of the available higher level technology and administrative capacity, with an active, on-site component that maintains permanent contact with the collaborating farmers. At both levels, teams should interact with outside related institutions and individuals as conditions demand.

2. Operational

The teams' activities should contribute to defining, conducting, and implementing the diagnosis, testing, validation, and dissemination stages of FSR/E. This includes identifying specific assignments for the team members in realizing the Sondeo, developing workplans, and analyzing results. Actual planning and/or establishment of exploratory, refinement, and validation trials, providing logistical support for field activities, record keeping and follow-up action with farmers are important team activities. A short term and medium term program for carrying out activities should be agreed upon early in the implementation phase of the FSR/E teams.

3. Networking

The organization of channels and procedures within established levels of the FSR/E team and related specialized, regional, and international institutions should be encouraged to foster permanent two way communication.

4. Training

A permanent training strategy to update required expertise among permanent and new personnel should be defined. This should include short term, academic and in-service training locally and abroad.

Composition

Ideally, the multidisciplinary nature of the FSR/E team should include participation of specialists from the social and biological (crops and animals) sciences and from the supporting research and extension institutions. This is no easy accomplishment, but an approximation of the best representations from the related institutions should be pursued.

As previously mentioned, a bi-level FSR/E team should be considered: a senior team component made up of discipline and commodity program specialists from research and extension and including expatriates, when available, should operate from a central location to direct and coordinate the activities of a number of field teams. The field team component should consist of full time junior level staff, multidisciplinary in nature, actually living in the farmers' community. These localized field teams components should have sufficient autonomy and technical capacity to carry on the established routine, follow-up, and analysis of results of the on-farm trials in their assigned area.

Each field team component should also include the full time participation of one or two extensionists that, together with other researchers and social scientists, carry on all the field activities. The importance of having extension personnel closely integrated in the research activities of both the senior and field team components is to strengthen the necessary collaboration between research and extension that would result in a shared "parenthood" of the recommendations coming out of the system.

The composition of the FSR/E team components should be as permanent and committed as possible. At least the care of few full time individuals should receive collaboration of other specialists from the same or outside institutions under and agreed time commitment.

As it is practically impossible or economically infeasible to be able to include all disciplines and institutions theoretically required, the composition of the senior and field team components' staff needs to be adjusted to include the closest, best available human resources.

The size and specific composition of each senior and field team component will vary according to available human and physical resources. For the senior team component, a minimum number, to include the commodity and discipline program directors and extension representatives, can be considered. For the field team components a minimum of four junior personnel, where one should come from the extension institution, can be considered. Academic traning at the B.S. and technical level, with the coordinator perhaps at a M.S. level, should be adequate to constitute a field team component. However, the ideal number of personnel in each team component will be dependent on resources available and area to be attended.

Implementation

The most difficult aspect in implementing the FSR/E team is probably its institutionalization within already existing research and extension institutions. Unless the senior members of these institutions understand and accept the merits of the FSR/E approach, the concept will not be able to function properly. Many times it constitutes a diplomatic challenge to introduce and convince traditional key personnel of the fact that the FSR/E approach strengthens and improves the impact possibilities of their activities rather than competing with them. The senior team components of FSR/E offers the opportunity to channel their expertise and hierarchical capacity in behalf of the FSR/E approach. Existing resources can also be better incorporated or made available to the field level team components once the on-farm activities are appreciated by the key personnel as part of

the senior team that in close interaction with the field team implement and feed back the priority decision previously taken jointly.

The gradual establishment of the senior and field FSR/E team components is advisable. A starting unit can be a pre-existing geographical region or a main experimental station. From this unit, where the senior team component should operate, a number of dependent field team components can be organized, according to the human and physical resources available.

A short, medium, and long term expansion strategy should be defined to establish field team components in the starting unit(s). Other regions or stations should be eventually established taking in consideration budget allocations, training efficiency, and political priorities.

An operational mechanism that allows for an effective interaction of team members, between senior and field team components and among them, as well as with related institutions, needs to be programmed. At the senior team component level, management, budget and resources allocation, regional and/or national policy priorities, training and networking with other institutions should be considered.

At the field team level, identification of local problem and research priorities should be considered and permanently adjusted in collaboration with the senior team component members.

The following minimum joint senior and field team component activities should be considered:

- Sondeo.
- Work plan discussion and priority definitions.
- Analysis and results of on-farm trials.
- Specific training and follow-up activities.
- Review policy and financial decisions.
- Monitor on-farm trials and contribute to their design.

The field team component should have full responsibility to implement the kind and number of trials agreed upon in the work plan. These include the identification of collaborative farmers, the allocation of trials according to their objectives, management and technical observations required, and the analysis and interpretation of trial results.

The bi-level FSR/E team proposed allows for a multiplication effect of the available senior research capacity. It also facilitates a commitment of participation of the research and extension institutions by causing a minimum of disturbance in these institutions. Researchers will be better able to conduct more meaningful and effective trials and the extensionists will receive farmer-proven technology recommendations to whose definition they have contributed.

In summary it should be stressed that effectiveness in properly conducting a Farming Systems Approach to Research and Extension will be highly dependent on the human resources available. The organization of the participation of decision makers and practitioners within a sound structure that allows for maximum efficiency for all resources available is necessary. This can be achieved through the best understanding and integration of the function, composition and implementation of a bi-level FSR/E team.

COMMUNICATIONS IN FSR TEAM-BUILDING: THE INTERDISCIPLINARY RESEARCH TEAM

Donald L. Esslinger and Constance M. McCorkle

INTRODUCTION

The overall aim of FSR/E projects is to have a lasting effect on the productivity and well-being of people. Constant and effective communication, both external and internal to a project, is necessary to that end. Here, we address the need for more such communication on FSR/E projects in general, and on the interdisciplinary FSR research team, in particular.

FSR/E has evolved out of a need to find better approaches to agricultural development. It is interdisciplinary in nature, and it emphasizes farmer involvement in ways that are new and different from those previously practiced in the United States or other countries. When we aim to analyze and solve problems with an interdisciplinary and farmer-feedback approach, by necessity we commit ourselves to operating in new, interactive ways. The way we work together, share information and outlooks -- in short, communicate with each other -- is critical in bringing multiple disciplines and farmer viewpoints to bear on a problem.

One way to look at the many communication aspects of FSR/E is to build a matrix which will allow project management to focus upon the goals or objectives for which good communication is most critical, and then build new communications strategies into the project design. At this more global level, emphasis should be on external as well as internal communication. The matrix could logically include seven or more goals or objectives.

1. Consider the farm family and the farming operation as a unit. This lies at the heart of FSR/E methodology. Who is the farmer, the tenant on the land, or the landowner who may be making many of the decisions concerning new technology? We frequently hear about how much of the actual farming or livestock rearing is done by women and children -- whether in Africa, Latin America, Asia, or the U.S. The complex interrelationships between production for family consumption and for cash income also must be considered, along with the potential for non-farm income.

2. Know about farmers' exchange of information. We need to know about farmers' organizations, their objectives, and activities. More particularly, we should learn about farmers' sources of information, the kinds of information they seek, and the relative importance and confidence they place on these different sources and types of information.

For example, during a recent field day in Tunisia, farmers said that they like to get certain information from radio or television. What they were talking about was awareness. But they also came to a field day to see experimental techniques and varieties for themselves and to compare notes, as it were, with the farmers who cooperated in the demonstration trials. The value of firsthand verification and of farmer testimony became an important part of our knowledge base about the target audience's information desires.

3. Ensure farmer input into research and extension. With research conducted in farmers' fields, this objective should be the spark of FSR/E. When

agricultural extension was in its infancy in the United States, the resource base was drawn heavily from farmer experience. For example, we have long known the benefits of studying innovators. But how much input into research do farmers really have when we conduct research in their fields? That may depend on the opportunities we have for communication between farmers and the research team. USAID Administrator McPherson once noted that many extension organizations lack the ability to gather information from farmers. Is that also being said about the research organizations in countries in which we work?

4. Develop/strengthen the reporting of research. When we collect base data about farmers, farming practices, farming problems and the like, we also should be gathering information from other sources that provide a characterization of the information system. That knowledge will help us decide how to package information, which media and channels to use, the different audiences to target, and other necessary dissemination issues to address. An inventory of channels and media should include government, private, and commercial agencies and organizations. Researchers are information users as well as information generators; so we should also give close attention to library and documentation services, and to the handling and distribution of in-house materials such as correspondence, memoranda, trip reports, committee reports, and position papers.

5. Collaborate with government agencies, public and non-profit organizations, and the commercial sector. FSR/E projects do not operate in isolation. Government agencies may be working with the same audiences and/or on problems related to those prioritized by the project. Likewise for public or non-profit organizations. And commercial companies that buy and sell among farmers can be valuable information sources and collaborators. Communication with these other agencies and organizations at all levels of operation can greatly facilitate FSR/E work. While we all recognize this fact, how often do we actually actively explore these potential research and extension linkages?

6. Understand communication between research and extension administrations and the FSR/E project teams. This objective refers to how agencies and information flows are organized both vertically and horizontally. The difference between formal and informal modes of communication within this structure also needs to be described. I.e., one must look beyond formal lines of responsibility to study how information is actually developed and delivered.

7. Build in interaction among and between researchers and extensionists. Two-way communication among and between research and extension teams is vital. It must be accomplished even though, as is often the case, two or more different organizations are involved.

It is not enough just to write a set of communication objectives. Although this is a necessary first task which calls for considerable time and energy, in itself it does little to provide the means of communication. To do so, and to complete the matrix, another axis must be constructed. This axis minimally includes three parts.

A. Describe the conditions that must be present to allow the communicative objectives to be met.
B. Determine what activities are necessary to work toward each objective and who has responsibility for bringing about the prescribed conditions and desired activities.

C. Define the standard for success and how progress will be measured.

Leaving aside this larger model of FSR/E communications, this paper deals with only one of the 21 cells in the matrix. We focus on communication problems -- and some solutions for them -- in just one of the many sorts of teams involved in FSR: the interdisciplinary research scientist team.

COMMUNICATIONS ON THE RESEARCH SCIENTIST TEAM

Here, we refer to a team of research scientists -- the kind of group that might include persons from various soil, water, plant, animal, or other biological sciences, agricultural engineering, and social sciences like anthropology, rural sociology, economics, and agricultural economics. The research team may be organized with a team leader, and it typically (though not always) works with the support and direction of an administrator. Rarely does it incorporate a communications expert, however.

Naturally, other types of teams are included in the larger FSR/E effort -- government officials, project administrators/principal investigators, field interviewers, extensionists, and farmer- collaborators. In fact, the research scientist may be a member of some of these other teams as well; there is often an overlap between these groups at adjoining levels. Communications within and between each of these different functional types of teams would provide material for many papers. However, the research scientist team is perhaps especially problematic. Its constituency is often more diverse than that of other FSR units -- in age, sex, race, nationality, professional status, and above all, scientific discipline. When people from several disciplines are expected to interact within and contribute to a team effort, they are particularly liable to run into communication short-circuits and breakdowns that slow or blunt team impact. Our aim here is to look at the practical, everyday communicative activities of this many-headed monster, the research scientist team. We have organized our comments under three headings: (1) communication problems inherent to the research team, (2) where communication can be improved, and (3) how communication can be improved.

Communication Problems Inherent to the Research Team

If nothing else, the professional jargon of different disciplines can sometimes close the door to effective communication. This is not surprising, since on occasion we even experience difficulty in communicating within our own disciplines. When we try to work across disciplines, the terminological problem is magnified several times over. Each scientific discipline has its own jargon -- a technical vocabulary that is unique to that field. Moreover, scientists may coin new words, or use old words to mean something quite different from the layman's meaning. The "jargon barrier" is one common and simple example of some of the communications breakdowns that research teams encounter.

Closely related to this problem is the understandable tendency of each discipline to identify, define, and address FSR/E tasks according to its own methods, models, and outlook. A plant breeder, for example, may see a new variety as the ideal solution to a given cropping problem. The hydrologist may instead think that more or more timely delivery of water is the key. The economist may argue that pricing policy alone is sufficient to resolve the matter. And the anthropologist may opine that it is best to do nothing at all! These examples could be multiplied by as many disciplines as one can find in FSR/E. The point is, this diversity of opinion and approach is not bad. Quite

the contrary -- it is the overriding strength of FSR/E. Ideally, it should lead to more culturally and technologically appropriate, ecologically sound, and cost-effective solutions that accord with the real-world complexity of farming systems.

In arriving at these integrative solutions, communication across disciplines is essential. Yet fully trained scientists who have spent years acquiring a profound knowledge of their field are naturally inclined to work within the scope of that expertise. They may be reluctant to venture into the no-man's-land between disciplines. This can be a difficult and confusing experience, as one leaves behind one's tried and true disciplinary paradigms for uncharted research territory.

Furthermore, there is often little to motivate the scientist to embark upon this extradisciplinary journey. Our research reward system generally does not encourage the sort of interdisciplinary interaction that is necessary to FSR/E. Academic positions are usually defined in precise subspecializations. The most prestigious journals are often the most narrow and field-specific. Moreover, scientists on an FSR team often lack the leisure to craft so many scholarly articles as their more academic peers. And although both are burdened with the struggle to keep abreast of information flows in their own discipline, the FSR researcher must absorb a great deal of information from other fields as well.

As noted above, research teams commonly operate under a team leader. The way this role is handled can impact the way the team works and the final results of its research endeavor. A dictatorial leader can easily stifle input from some members. Conversely, one who is too laissez-faire may not provide enough structure for effective team communication and action. One of the most important jobs of a team leader is to stimulate activities that promote the productive flow of information and ideas among the team members.

Cultural differences, too, can affect the way a group works. It is not unusual to find a variety of nationalities on a research team. Their attitudes toward team communication may vary accordingly. Some cultures expect to have a lively exchange of ideas by speaking out, confronting one another with new facts and insights, and even arguing. In contrast, others place a premium on downplaying open conflict, and discourage the frank expression of individual opinion. These two different perspectives (and there are still others) can lead to some uncomfortable moments.

Finally, further cultural and socioeconomic differences can be a hurdle to good communications in some groups. Team members may vary in age, sex, marital status, religious and other organizational affiliations, education, salary, social position, and in status indicators like dress, place of residence, or what-have-you. This disparity can exacerbate disciplinary differences and impair communication flows if no steps are taken to cope with it explicitly.

Where Communication Can Be Improved

In our experience, we have noted several very basic areas where difficulties arise in evolving a shared understanding of team tasks and integration -- and hence where improved communications could be of great benefit. The following three areas hardly exhaust the list, but they appear to be especially common problems on FSR/E projects everywhere.

One of the very first places where communications breakdowns can occur is in team members' view of project objectives. It is all too easy to assume that everyone shares the same perspective on project priorities. Such an assumption is dangerous. At the outset of a project, one of the first communicative chores is to hold a discussion among all team members of the written project objectives. (If they aren't written, this becomes a prior task). This should include a free-ranging exchange about the overall situation and background of the project, to make sure that everyone has the same information and understanding. This is the time to seek clarification from superiors, further explanation, to re-check the outcomes or products expected of the team, and so on. Sometimes even the definition of the subject matter of research can be problematic. What seemed straightforward enough, at least as conceptualized before beginning work in the field, can shift radically when confronted with the reality of local farming systems.

Equally important is reaching a common understanding about team, as well as overall project, objectives. If scientists see the team objective only in terms of their own areas of expertise, something like the reverse polarity of magnets can ensue, and the team will fragment. How each discipline can best contribute to team objectives needs to be negotiated and spelled out as clearly as possible. In the process, team members must also reach a consensus about their respective roles in group action and decision-making. Critical to both these processes is a mutual respect for the various disciplines involved.

Not only must each scientist's contribution to the team effort be delineated; there must also be a plan for integrating these contributions. Yet how often have we heard the complaint that there is no cohesiveness in the research effort because scientists are working only on their individual projects? And that they never collaborate, coordinate, or communicate with the other teams members as they ought? In this regard, it is critical for members to recognize that the team objective takes priority over individual research agendas.

How Communications Can Be Improved

This could be a full curriculum or just a few tips to take home and put to use. We have chosen the latter. Although there is a healthy literature on team-building communications in fields like business management and industrial psychology, it is not always directly relevant to FSR/E. Here, we do not reference that literature; instead, we offer some practical suggestions for improving research team communications that are largely based on personal observation and on examples of real situations we know about. And rather than follow any of the popular communications models -- for example, Berlo's SMCR (source/message/channel/receiver) framework or Schramm's (1961) and Shannon and Weaver's (1964) well-known models -- we group these strategies into four categories phrased in terms of increasing the quality, frequency, intensity, and variety of channels in communicative events.

Quality. There are many qualitative aspects of the communicative process that could be considered here, but we want to point to one that is too often overlooked -- listening skills. As many communications experts have noted, if we would just listen better, this alone would lead to more successful communication. Some authors believe that listening is at once the most used yet least appreciated aspect of daily communication. For example, a frequently cited report (Nichols 1957:6) finds that many of us spend 70% to 80% of our

waking time in some form of communication, of which nearly half (45%) is devoted to listening. (Of the remainder, 30% is spent in speaking, 16% in reading, and 9% in writing.)

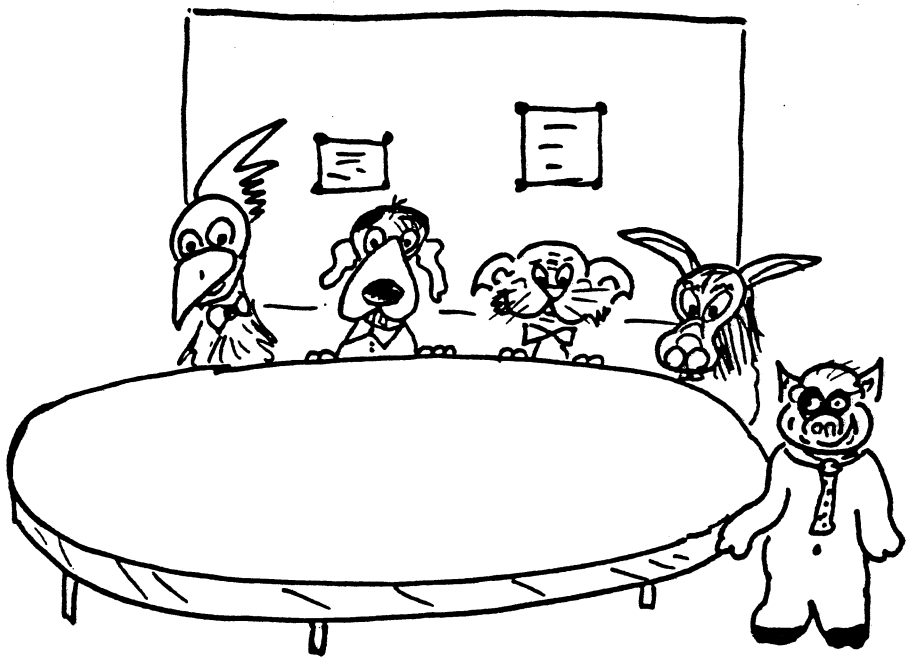
According to Nichols, we can improve our listening skills through three simple exercises. (1) Anticipate the speaker's next point; this will let you know whether or not you are understanding the message correctly. (2) Identify the supporting elements of a message, as represented in explanations, emotional pitch, factual illustrations, etc. (3) Make mental summaries periodically as you listen. These exercises make listening an active rather than a passive communicative event. And they will quickly help sort out where your and your teammates' views of an issue diverge or agree. (Figure 1)

1. Listening Skills

Frequency. Simply increasing the number of opportunities for exchange of ideas and information is an obvious starting point for improving team communications. The more communicative events there are, the more likely that messages will be sent, received, and understood. As noted earlier, one function of a team leader is to provide for regular interaction among team members. This interaction can take many forms, as we will see in the dimension of channels. Of course, in designing both the type and frequency of communicative events, time and distance constraints must be taken into account. (Figure 2)

Regular meetings of the full team membership naturally should be a feature of every FSR/E project -- the more often the better. For teams that are far-flung in remote areas, perhaps with transportation shortages as well, the frequency of such meetings will be lower. In such cases, other strategies must

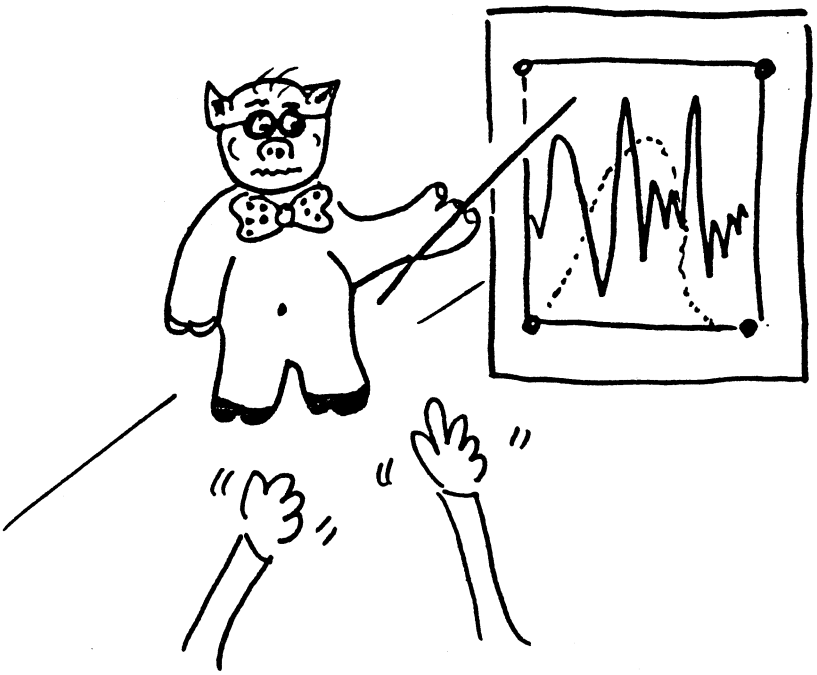
be sought to keep up the frequency of communications. For example, on one project on which the second author worked in West Africa, team members were posted to different regions, as much as 400 km distant from each other. Moreover, they were faced with uncertain transport, and with unreliable or no phone or wire service. To help offset this communications gap, a monthly report was instituted. In it, each team member would describe her/his research accomplishments, problems, insights, immediate plans, logistic or other needs, professional contacts made, suggestions for new project activities and research foci, and so forth. Along with budget and equipment news from the administrative end of the project, this monthly report was compiled in the project office in the capital city and then distributed to team members, and to the project directorship back in the U.S. When the team then reunited for its aperiodic meetings in the capital, these in-house reports served to focus discussions and save time in catching-up on each others' doings since the previous meeting.



2. Regular, Frequent Meetings

Aside from regular project meetings and written reports, another useful strategy is to establish a series of semi-formal colloquia on research in progress, with team members taking turns at reporting their findings to date. Such colloquia serve as a forum where researchers can react to each others' work in an organized way, provide constructive criticism, and explore the touchpoints between disciplinary investigations through joint analysis of concrete data. Colloquia can also be used to invite special guests who may be passing through the project area or speakers from other projects there, both of whom can often provide fresh perspectives on the team effort. On one project in the second author's experience, such colloquia rotated among all the team

members' homes, with spouses welcome to attend. Preceded by cocktails and followed by dinner, these soirees provided an especially congenial, commensal atmosphere in which to debate research findings. (Figure 3)



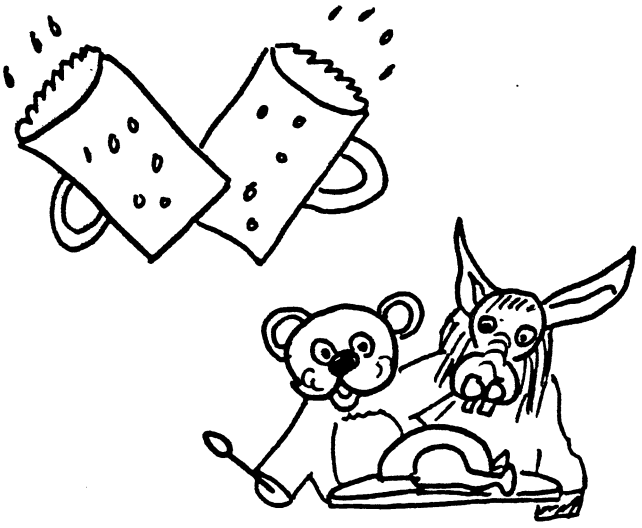
3. Semi-Formal Colloquia

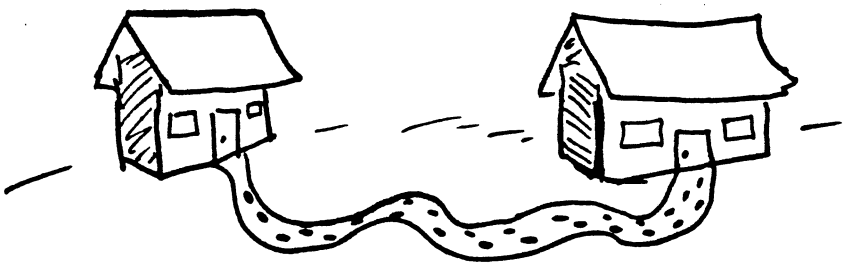
This last example suggests that not all communicative events among the team need to be structured and/or formal. And not only team leaders can initiate interactions. A great deal of successful communication takes place in the equivalent of hall-walking, over meals, at parties, in visiting back and forth between team members' homes, or in situations like having a drink or engaging in games, sports, and exercise events together. Team members and leaders both should contribute to the frequency of such events. Their more casual and social definition often opens up more free-flowing lines of communication that are blocked in formal contexts; and they can do much to overcome cultural and status differences, and build a solid sense of team-ship. (Figure 4)

Intensity. Increasing the intensity of communicative events can reinforce and, especially in long-distance situations, partially substitute for the frequency of communications. By intensity we simply mean events where individuals are in close communicative contact for hours on end across days at a time. This category includes gatherings like workshops, retreats, conferences, team trips, and lengthy special-purpose sessions, e.g., for project planning, evaluation, or review.

One example of the latter is drawn from the first author's experience at the International Rice Research Institute. There, once a year, a week-long, essentially day-and-night internal review of all ongoing research was held. Scientists found this a grueling period, but in the end they agreed that it was necessary to continued project integration and research coordination. A similar example is the annual planning seminar which takes place on the MIAC

(MidAmerica International Agricultural Consortium) Farming Systems Research Project in Tunisia. Some 30 Tunisian FSR researchers plus their U.S. core consultants gather for several days of frank discussion of the project's achievements and shortcomings across the year past, and to plan accordingly for the future year.

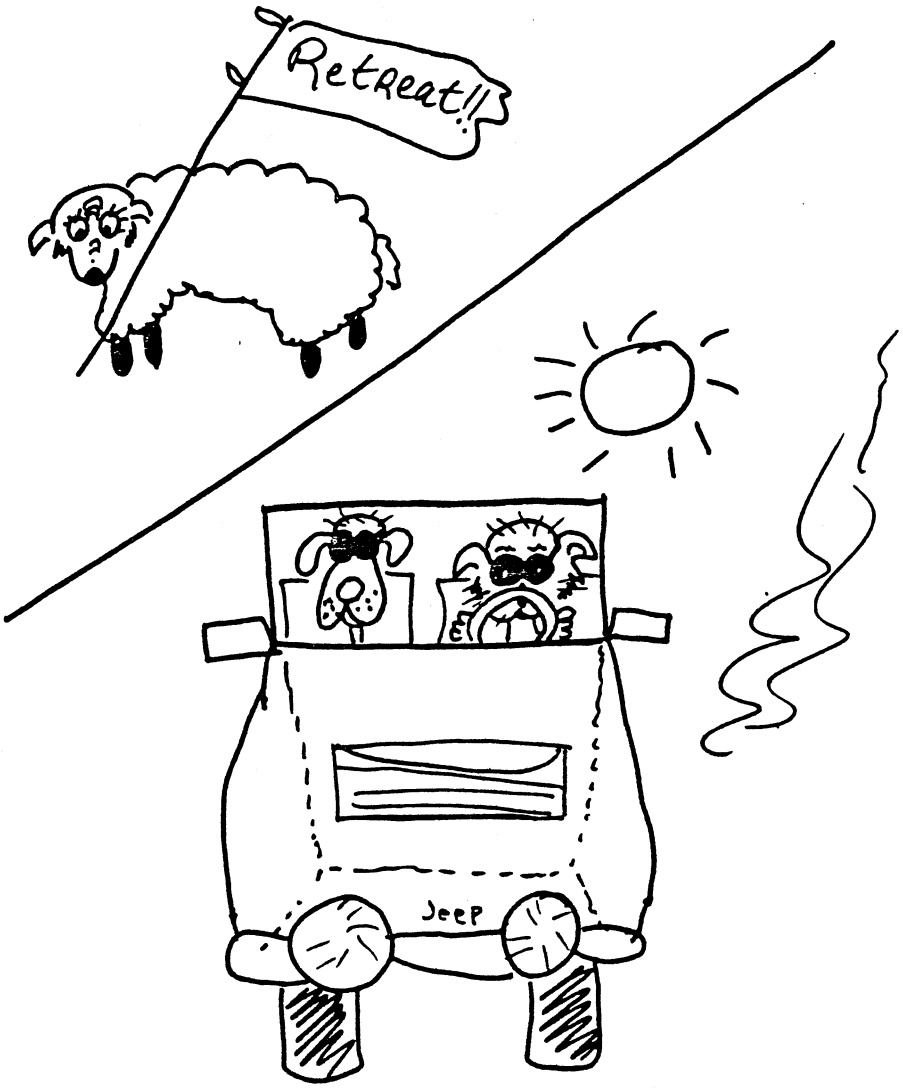




4. Informal Interaction

Retreats offer another opportunity for intensive communication. At the Missouri campus, we do a lot of "retreating." There are teaching retreats, department chair retreats, deans' retreats, and even Small Ruminant retreats! Sometimes a retreat -- where you physically remove yourself from the usual manifold interruptions -- affords the only opportunity to work past the many communicative barriers, really concentrate upon a given task, and see it through. Team travel provides essentially the same opportunity. During the many hours or days spent hunched on international flights, lurching across rough country roads, or trudging around to farmers' homes, team interaction and communication can reach a zenith. (Figure 5)

Workshops afford another setting for intensive communication. Theme-oriented workshops can be especially useful in tackling specific research and extension problems from an interdisciplinary stance. This was the case, for example, in the ICRISAT/IDRC/SAFGRAD/IRAT workshop on farmers' participation in the development and evaluaiton of technology. This six-day symposium was attended by more than 50 researchers from 20 countries representing all relevant technical and social science disciplines, and it included scholars trained in both French and North American traditions of farming systems research (Matlon et al. 1984). The workshop format was one of formal



5. Intensity of Communication

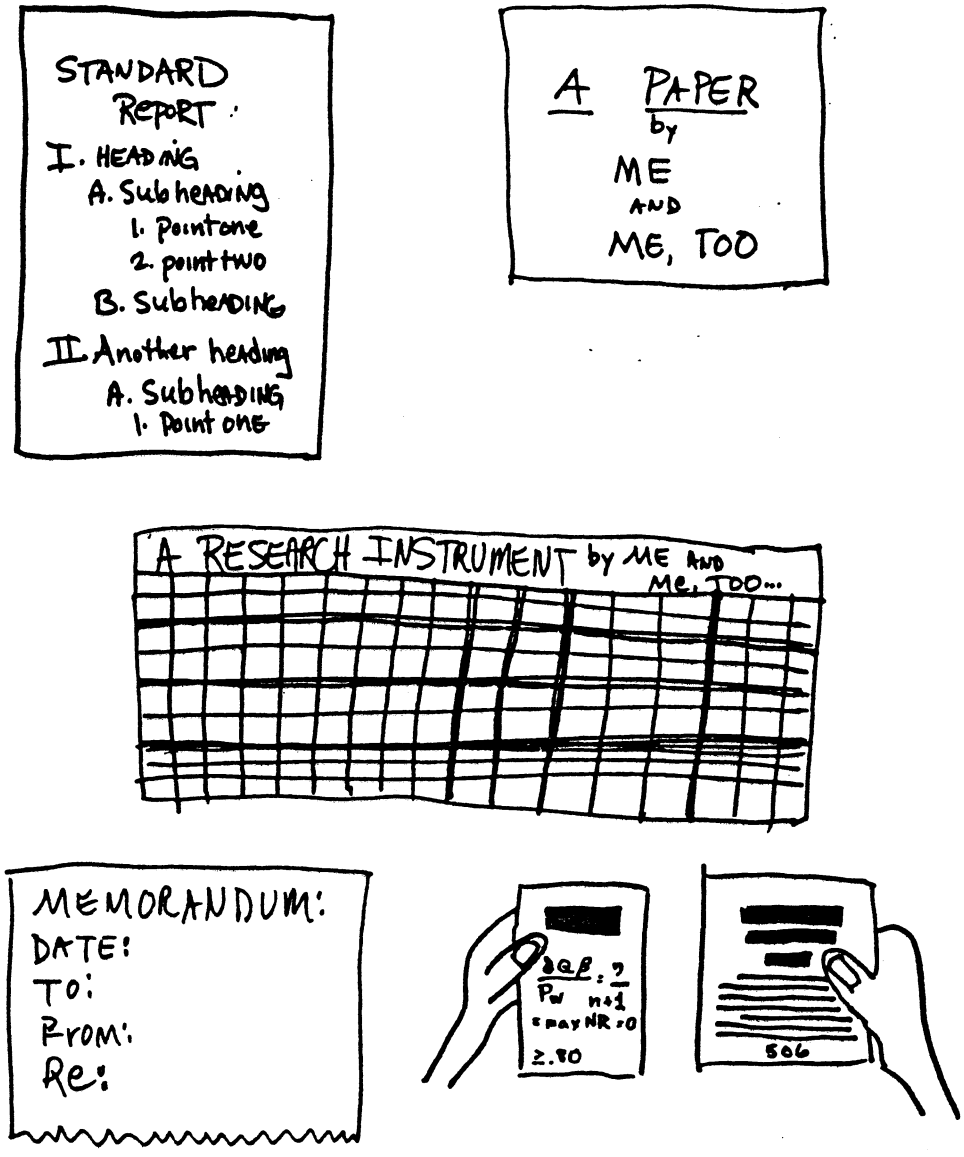
presentations in the morning, followed by afternoon small-group meetings to review, react to, and contextualize the morning discussions. This sort of structure was invaluable for helping individual research teams to discover fresh ways of integrating their own work based on the observations of interdisciplinary FSR/E workers worldwide.

Conferences like the annual Farming Systems Research & Extension Symposium provide another setting for this kind of dynamic exchange. And themes like that of the 1985 conference -- management and methodology -- should particularly help to forge common, cross-disciplinary understandings of FSR/E structures, terms, and techniques.

Variety of Channels. Communication can take place through a variety of channels -- most commonly written, oral, visual, and kinesic/proxemic. In sending and receiving messages, the greater the variety of channels utilized, the more likely the information will get through. We have already mentioned various written and oral strategies in team communications, but here we would like to add a few more, and to suggest some uses for visual and

kinesic/proxemic channels, as well.

With regard, first, to written channels, the need for regular reporting of individual and joint team activities cannot be overemphasized. For some research teams we have encountered, this process is viewed -- even on a quarterly or biannual basis -- as nothing more than a useless bureaucratic nuisance. But regular reports are one way for interdisciplinary teams to communicate the real substance of their differing investigations and to keep track of how well, or if, these investigations are meshing. For teams that find this an especially difficult or onerous task, sometimes it is helpful to draft a standard outline for project reports to aid them in organizing and putting on paper the relevant information. (Figure 6)



6. Written Channels

Another strategy in the written channel is for team members from different disciplines to co-author papers and articles. This is one of the best -- if not the easiest -- ways we know of to promote truly inter- as versus multi-disciplinary farming systems research. To help stimulate this kind of joint communicative endeavor, establishment of a project publication series for co-authored papers is a good motivator.

Relatedly, jointly designing -- and later, jointly applying -- research instruments such as surveys and their code sheets, ranking scales, open-ended questionnaires, and so forth has proved a successful integrative technique on several projects known to us. Not only does this strategy get team members working together on a concrete task, but it also begins to build some knowledge of and respect for their respective expertises. Even better, it helps ensure that data gathered by one discipline will be sensitive to research issues and information needs in other disciplines on the project.

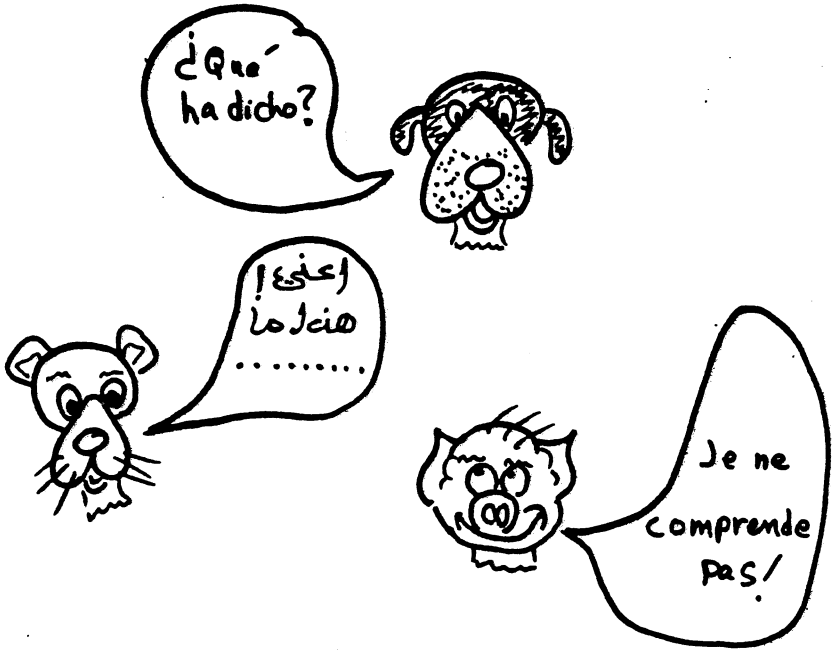
Reading, as well as writing, papers and articles together offers another means of communicating across disciplines. On some teams we have worked with, we have found that exchanging a key article or two can do a lot for the jargon problem. A carefully chosen article or text can elucidate disciplinary-specific concepts or philosophies and their terminological correlates. Whether on a one-to-one basis or in a reading-group format, this kind of exchange is a non-threatening way to introduce colleagues to different scientific perspectives and to build a common vocabulary.

A further team-building reading strategy is systematic sharing of project-related correspondence, memoranda, trip reports, and etc. This can be easily organized in a number of ways. For example, SR-CRSP (Small Ruminant Collaborative Research Support Program) team members at the Missouri campus have established a chronologically-arranged reading file in a central place. Each individual contributes copies of documents sent or received (from any of the ten universities or five country sites involved in SR-CRSP, or from USAID or other sources) by which contain information useful for other members of the in-house team. This information may pertain to any aspect of project functioning -- whether research, administration, logistics, budget, internal or external politics, travel plans, etc. When items are urgent or of time-sensitive news value, they may instead be circulated to the team by routing slip. Particularly critical or informative documents may be copied and distributed to all team members for their individual files. These techniques are real time- and memory-savers. Like regular meetings and reports, they keep people current on project events, assure that they all have access to important information, and save significant person-hours in discussions or in updating team members who have been absent for some period. This team-building communications strategy has the added advantage of keeping things "above board."

One last type of written exchange we would like to mention is the memorandum. This lowly literary form is often overlooked. Recalling the fact of cultural differences in communications, in at least one Asian case we know of, institution of a system of memoranda saved the day. Sensitive to status differences and mindful of oriental politeness, in regular project meetings team members would rarely express their true feelings about issues on the table. A seeming consensus on actions to be taken would be reached in the meeting, only later to encounter silent resistance. However, if subsequently asked to respond to meeting discussions individually and confidentially in a

written memorandum to the team leader, members would then enunciate their real opinions and arguments. Better project planning resulted. At times, this memorandum-response technique is also useful in other cultural contexts insofar as it allows time to mull over issues and then respond in a more thoughtful, less spur-of-the-moment fashion. However, this technique must be applied judiciously. Sometimes a verbal exchange may be more friendly and appropriate. At other times, people may simply be reluctant to commit themselves in writing.

The foregoing example leads us back to the oral channel. Here we will comment on just one factor -- the choice of language used. On teams with an international composition, this can be a critical consideration. Members who are less fluent in the lingua franca of the project may feel left out or at a distinct disadvantage in expressing their ideas and arguments. This can indirectly exacerbate disciplinary or other differences. In such cases, the team as a whole should take care to see that -- whether by translating or by shifting languages -- messages are getting through to their membership. (Figure 7)

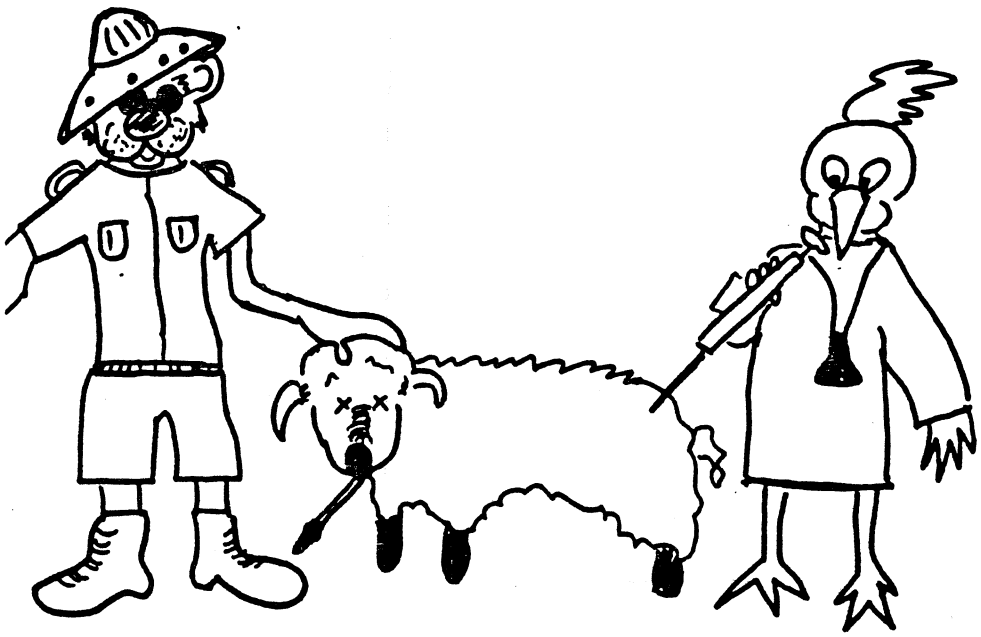


7. Oral Channels – Choice of Code

For example, at a meeting of an international FSR team at CATIE in Costa Rica, one Spanish-speaker felt he could not fully formulate his explanations on a complicated subject in an alien tongue. So he asked a bilingual North American teammate to serve as an extempore translator for the English monolinguals. While, as we all know, translation takes time, on occasion it can be time well spent in that it allows team members to make their best input to the communicative exchange. Similarly, language shifts provide more room to express subtle meanings and implications, to explore how profoundly team members' perceptions diverge or converge, and to bridge both communicative and conceptual gaps. Moreover, occasional code shifts avoid the negative cultural

and psychological ramifications of using always and only one of a team's shared languages.

Joint hands-on activities are an immensely important communicative resource in team building. They simultaneously incorporate oral, visual, kinesic, and sometimes also written channels. In FSR, one of the most common settings for these sorts of events is the farmer's field or pasture. The research problems and goals of different disciplines become much more comprehensible if scientists can see, handle, and remark upon their real-world correlates together. While this is a truism in FSR, perhaps it bears repeating. To give just one brief example, as the second author recently noted in her SR-CRSP research in Peru with a Colorado State University veterinarian, inspecting and handling diseased animals in stockowners' corrals while listening (remember listening?) to her veterinary teammate's running commentary brought home the multiple variables involved in the animal health issues they were addressing. And the veterinarian's stay in the Andean village with the social scientist in turn sensitized him to some of the complex socioeconomic and cultural considerations impinging upon their joint research design. Doubtless all of us could multiply this example many times over. (Figure 8)



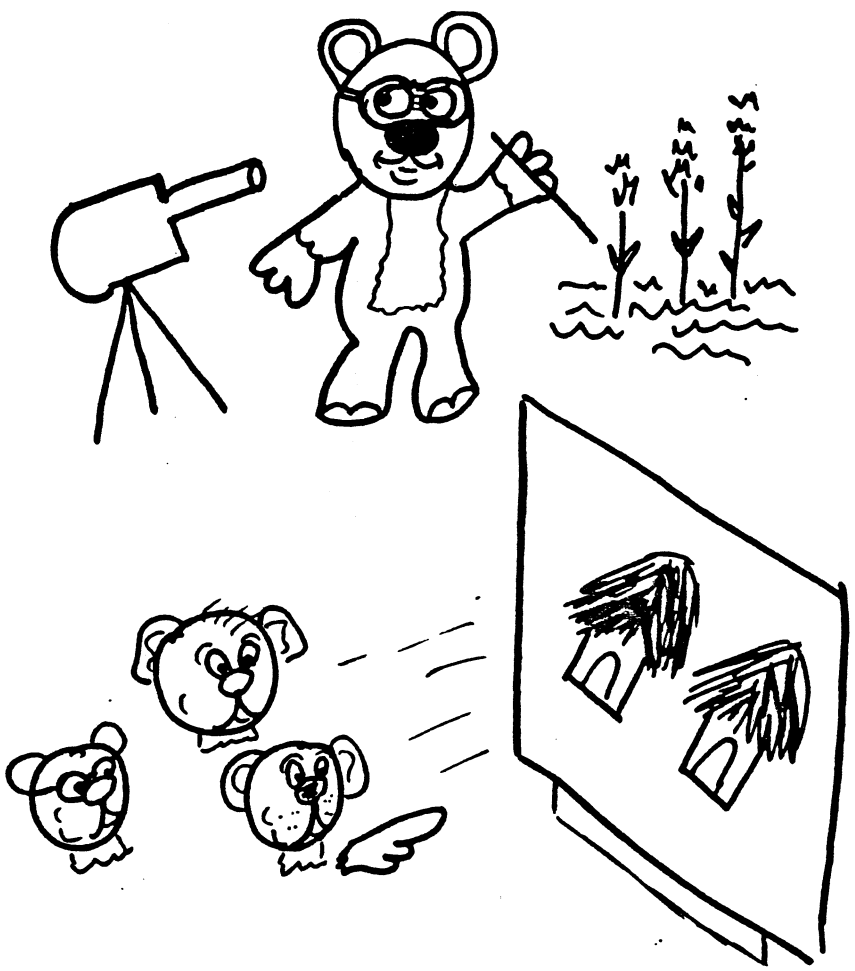
8. Joint Hands-on Activities In The Field

Even when such shared, hands-on events are somewhat less than successful, they can dramatically point up to team members where and why better communication is required. This was illustrated in a field day in Tunisia attended by the second author. Project researchers in the soil and water sciences, plant genetics and pathology, agricultural engineering, and socioeconomics participated in the event, in addition to farmers. Its stated aim was to explain to farmers the rationale and results of the on-going field trials. In the process, it became embarrassingly obvious that too little team communication had been taking place. For example, when farmers raised a point about the salty soil type of one field, the plant pathologist began to contest

it, until the soil scientists mentioned that they had already taken samples and that, indeed, the farmers were correct. But no one had reported the findings of the soil analyses either to the farmer who owned the field or to the rest of the team! An agricultural engineer later complained that one field had been plowed down the slope, without his knowledge. The input from socioeconomists into the selection of the farmer/collaborators was not at all clear. Finally, it was also evident that technical scientists could have benefitted from some tips from social scientists on how to conduct farmer-researcher dialogues in a more organized and egalitarian fashion. At the conclusion of this field day, nearly every researcher present left with a sense of the real need for increased team communication.

Turning now to visual aids, this seems to be a relatively less explored resource in team communications. Of course, we are all accustomed to the use of slides, graphs, charts, chalk boards, overhead transparencies, and so forth in our classrooms and in our professional presentations. These can also be profitably utilized in team contexts. But here we would like to comment on the rich potentials for increased use of film and videotaping. (Figure 9)

Videotaping could be particularly apropos where team members are working across widely dispersed sites and have little opportunity to visit them all.

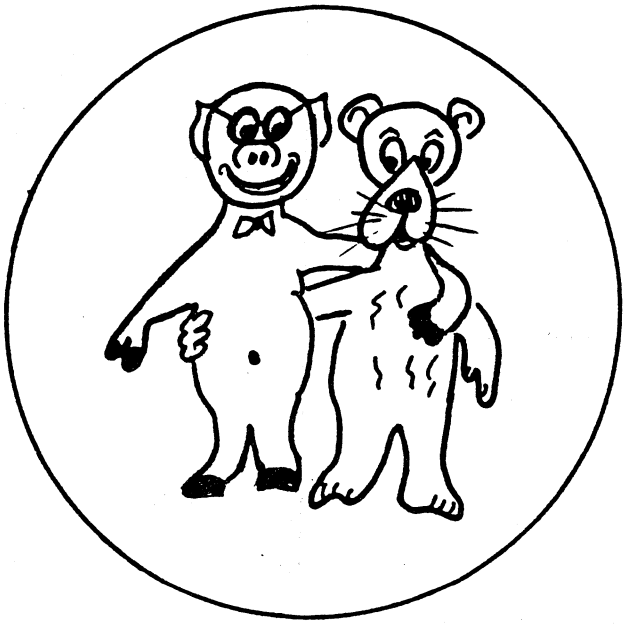


9. Visual Aids

Videotapes of scientists doing and/or explaining their field research in situ illustrating their research problems and methodologies, with other colleagues and farmers contributing their commentary -- this is the next best thing to the entire team's being there. If "one picture is worth a thousand words," then the value of videotape is incalculable. This graphic and dynamic communications resource could conceivably do more for understanding different disciplinary thrusts as they evolve "on the ground" and for identifying touchpoints with the other project disciplines than any other technique short of being there. Moreover, these visual documents will be sure to come in handy for all kinds of team-external communication needs as well.

Ethnographic films -- where these exist for the farming group under study or a closely related group -- can also promote interdisciplinary understanding. Of course, they constitute an excellent pre-fieldwork information and sensitization resource for team members unfamiliar with the culture in which they will be working. But more relevant here, judicious selections from this well-established film tradition could help technical scientists to understand some of the sociostructural, cultural, ideological, and economic realities with which their social science teammates will be grappling, and which will ultimately confront the design and delivery of appropriate technology. (For a complete, annotated listing of 1,575 such films and their distributors, see Heider 1983.)

Lastly, we will just mention one further communicative channel -- kinesics, or as it is more popularly known, body language. This is a somewhat "touchy" and very culture-specific channel. But it is one in which we are all, everywhere, constantly sending out messages -- usually unconsciously. This is not the place to review the fascinating cross-cultural literature on kinesics



10. Body Language

and the related field of proxemics -- the study of the cultural meaning and communicative use of space (cf. Hall 1959, 1966). Here we will simply note that culturally-appropriate eye contact, non-threatening body postures, a "pat on the back," a touch on the arm, a special handshake, an egalitarian and interactive arrangement of chairs in a meeting room: these can do much, in both formal and informal communicative contexts, to put across the message you are sending and/or to defuse interpersonal tensions. (Figure 10)

CONCLUSION

To conclude, we would like to emphasize along with Shaner et al. (1982:184) that "the key ingredient for true interdisciplinarity is interaction." One of the four critical components in their model of interdisciplinary synthesis and synergism in farming systems research and extension is "frequent and open communications." To this we would like to add that communication should also be of high quality, occasionally intense, should utilize as many channels as possible, and should take place in informal as much as (or perhaps even more than) formal contexts. Exploiting this full range of communicative options will improve any FSR team's functioning. Or as one of our colleagues at Missouri has succinctly put it, for successful interdisciplinary team-building you must "communicate, communicate, communicate -- and then communicate some more" (Nolan 1985).

Admittedly, this is a slow, time-consuming, and sometimes painful process, but it is an imperative one. And beyond the level of internal communication within a single functional type of FSR/E team, it also becomes a very complex process involving both internal and external communication networks among government offices (often of two or more nations), the farmer-public, multiple extension and outreach organizations, the media, universities, and other institutions. This complexity may seem a daunting challenge to the non-specialist in communications. In this regard, we offer one further conclusion: FSR/E projects need to include a communications expert on their team.

ACKNOWLEDGEMENTS

We would like to thank Learning Resources Specialist Mary Bixby, of the University of Missouri-Columbia Learning Center, for her illustrations of the text. In the case of the second author, preparation of the text was also supported in part by the Title XII Small Ruminant Collaborative Research Support Program under Grant No. DAN-1328-G-SS-4093-00. Additional Support was provided by the University of Missouri.

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MANAGEMENT AND TRAINING

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John S. Caldwell, Angela Neilan, Eija Pehu, and Segu Zuhair

IS FARMING SYSTEMS RESEARCH THE CART BEFORE THE HORSE?

Brook A. Greene

THE PROBLEM

Agricultural research personnel who previously were primarily concerned with biological problems in the field are now expected to undertake research in farming systems research and extension (FSR/E). They are required to focus research on the whole farm family and its behavior within production systems (Andrew, 1984). Agronomic and biological concerns have widened to include socioeconomic factors and vice versa. Thus, there is almost no aspect of field level, farmer-oriented agricultural research and linkages to extension systems that is beyond the purview of FSR (Biggs, 1985).

One key area, therefore, is that of training or retraining personnel to handle the additional complexities of FSR/E.

This paper argues that since at the moment field personnel are only partially able to carry out their subject matter research work, the extra burdens of FSR/E will make it much more difficult for them to be effective.

Hence, there is a need to pay careful attention to the type of retraining necessitated by the new emphasis on FSR/E. It cannot be expected that the present research system should suddenly be successful at carrying out FSR/E. As Meier says, ". . . educational capital stock cannot be changed quickly " (Meier, 1976). Complementary activities as well as activities in the correct sequence will often be required to be undertaken in order to obtain the desired results (Mosher, 1981).

Finally, there is little use in generating information unless field trials and surveys, for example, are properly conducted, data adequately prepared, analyzed, and reported by local research personnel who are then capable of continuing to carry out this research on their own.

In this paper, I have called the FSR/E package a cart. Because of the existing constraints, this cart can be said to be on a hill. It is held in place by a horse which I have called "sustained research capability" or the continuing ability of local research personnel to carry out FSR/E. The problem is to create an incentive to the horse so that it can pull the cart forward rather than be pulled backwards by the cart. The driver of the cart is generally more than one force.

One Potential Solution

Another way of framing this problem is to determine how to encourage field agricultural research personnel to participate in producing outputs useful for policy or decision makers, such as technical papers and reports.[1] The following simplified approach has been developed by the AESS program of the BARC[2] (Figure 1) to attempt to solve this problem:

Farmers provide assistance to FSR/E personnel. By means of appropriate short training courses, personnel improve their abilities to collect and analyze data and to put these into meaningful technical papers. Under supervision by more experienced personnel, this draft becomes a final draft from which a seminar handout is prepared. The original author presents the paper to an invited audience, and the original edited paper is then published by the research institute.

The Bangladesh Example

As of 1985, the national coordinated cropping system in Bangladesh included 16 sites (BARC, 1985; BARC, 1981) under the direction of seven agricultural research institutes.[3] Early in 1985, this system began to change towards FSR/E philosophy with the addition of more sites (26 sites in total) and the involvement of more institutes such as forestry, livestock, fisheries, and horticulture. This may be called the FSR/E cart.

Exsiting agricultural research personnel and the education capital stock is quite extensive. For example, the BARI had around 600 professional scientists in 1980 (15 Ph.D., 525 M.S.) in 19 regional and subregional stations. The BJRI had 161 scientists (8 Ph.D., 125 M.S.) in 6 research stations, 2 seed farms, and 24 subcenters. The BRRI had 131 scientists (23 Ph.D., 105 M.S.) in 6 main stations (Wennergren, et al., 1984). This is the capital stock which makes up the horse, a continuing research capability.

Problem areas have been well documented. Research facilities are inadequate in most institutes and organizational and management problems have often hampered effective research.[4] In Mosher's terminology, these are complementarities that must be attended to.

Other problems requiring a longer gestation period, as well as attention to the sequence of preceding actions (called sequences by Mosher), are also exemplified by the shortcomings in the performance and level of training of agricultural research personnel.[5]

In order to address some of the above problems, the AESS program of the BARC, for example, had implemented 20 short courses between 1982/85 with 316 agricultural research personnel drawn from most of the institutes, including extension and the academies for rural development[6] (Appendix 1). An important matter here is the proper sequence of participation in courses, as well as the applied nature using raw field data from local sites (Greene, 1983).

As a complementarity to these short remedial training courses, a series of training papers were developed (Appendix 2). These acted as guidelines to field personnel.

Following the sequence previously outlined (Figure 1), 14 seminar papers have been prepared and presented by field research personnel through July of 1985 and published in the AESS program seminar paper series (Appendix 3). A further 20 papers are under preparation, with numbers of participating personnel and institutes increasing.

SUMMARY AND CONCLUSIONS

The FSR/E package has been called the cart that must be pulled forward by continuing local agricultural research capabilities. Existing constraints mean that the cart is on a hill to begin with and is therefore in danger of pulling the horse back down the hill.

It has been argued here that in order to make the horse pull the cart, incentives are required. A system of incentives based on active participation by field research personnel in Bangladesh has been described.

The results of this process to date have been:

- to encourage central, regional, and substation agricultural economist personnel to prepare and present 14 technical papers;
- to thereby encourage the decentralization of data analysis;
- to strengthen a continuing research capability among young agricultural economists in the research system;
- to strengthen linkages between the BARC and other agricultural research institutes and personnel;
- to provide village level research results that should be useful for making policy decisions.

Footnotes

[1] There are many useful outputs expected, of which one is new technology to increase the incomes of the farmers.

[2] Under the direction of the director of this program, Dr. Ekramul Ahsan, Ph.D., Agricultural Economics, University of Hawaii.

[3] BARC, BARI, BRRI, BJRI, SRTI, BWDB, BAU.

[4] See Wennergren, et al., 1984, pp. 286-293, and IADS/BARC/USAID 1985, pages 77, 79, 80, 183.

[5] See Pearce, et al., 1984; Nelson, 1984, and Greene, 1984, for some discussion on shortcomings in applied statistical and agricultural economic training.

[6] The BARD in Comilla, and the RDA, Bogra. Other program areas of the BARC have also presented short courses as well as out of country training. See IADS/BARC/USAID, 1985.

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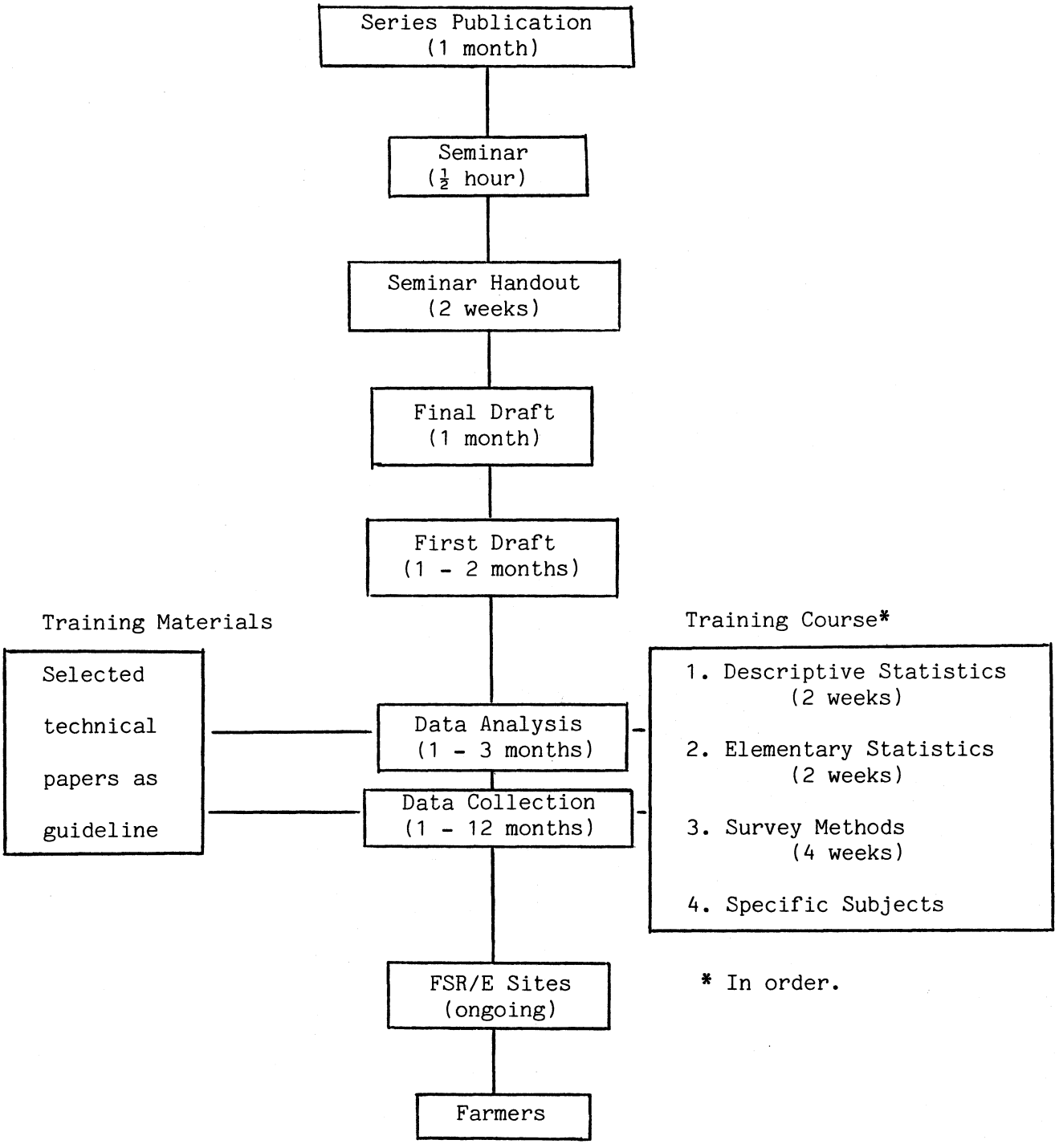
Figure 1. Creating Sustained Research Capability.



Abbreviations

AESS	Agricultural Economics and Social Science
ARP	Agricultural Research Project, BARC/USAID
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BAU	Bangladesh Agricultural University, Mymensingh
BJRI	Bangladesh Jute Research Institute
BSRTI	Bangladesh Sugar Research & Training Institute
BRRI	Bangladesh Rice Research Institute
BWDB	Bangladesh Water Development Board
BARD	Bangladesh Academy for Rural Development, Comilla
CSR	Cropping Systems Research
DLS	Directorate of Livestock Services
FSR/E	Farming Systems Research and Extension
FTR	Fisheries Technological Research
IADS	International Agricultural Development Service, now Winrock International Institute for Agricultural Development.
RDAB	Rural Development Academy, Bogra
S.O.	Scientific Officer, lowest professional level in Agricultural Research System. B.Sc. with some M.SC.
S.S.O.	Senior Scientific Officer. The next level above S.O. obtained usually after 5 to 10 years field experience and after obtaining an M.Sc.

APPENDIX 1

In Country Training Short Course

Agricultural Economics and Social Science Program B.A.R.C. 1982/85.*

1982/83

Descriptive Analysis of Research Data. 4 courses at 4 regional stations. 60 participants (Greene).

1983/84

- Application of Statistics in Ag. Research. (Univ. of Kent. IASR team, (UK) 1 course, 25 participants.
- Desc, Analysis Res. Data. 3 courses, 3 locations. 67 participants. (Greene).
- Soc. Econ. Data Analysis/Partial Budgets. 15 participants (Greene).
- Applied Cartography. 12 participants (Dhaka University).
- Aquacultural Econ. 20 participants. (ADC Consultant).

1984/85

- App. Stat. Ag. Res., 1 course, regional. 25 participants. (Univ. of Kent, IASR team, UK).
- Ag. Pric. Analysis. 11 participants. (Greene).
- Matrix Algebra & Calculus. 19 participants. (Greene).
- Desc. An. Res. Data. 15 participants. (Greene).
- Water Prod. Function. 22 participants. (Utah State).
- Multiple Regression. 24 participants (Kempson/Burrell, Wye College, UK).
- Survey Methodology. 9 participants. (Neely).
- Microcomputer. 20 participants. (Davy).

* Source: Annual Reports, AESS Program, June and July 1985.

IASR = Institute for Applied Statistical Research.

APPENDIX 2

A Selected List of AESS/BARC Training Papers

Paper Number	Title	Date
2.	Fertilizer Prices	July 1982
3.	Some Economic Ratios	July 1982
5.	Socioeconomic Data Analysis on CSRS	May 1983
6.	Rice Yield Analysis, Hathazari CSRS	April 1983
7.	Crop Yield Analysis, Jessore CSRS	April 1983
8.	Partial Budgets	May 1983
9.	Income Analysis, 1981/82, Jessore CSRS	November 1983
11.	Labor Use Standards for Selected Crops in Noakhali District	May 1984
12.	Ditto. Jute.	June 1984
14.	Using Index Number with CSR Date	March 1985
15.	Crop Yield by Land Type & Farm Size, Hathazari CSRS	March 1985

APPENDIX 3

Agricultural Economics and Social Science Program, BARC

Workshop Paper Series
(Up to July 1985)

Workshop #1: October 17, 1984; BARC, Dhaka

Author	Title	Paper Series #
Azad, A.K. (S.S.O.)	Agro-Economic Comparison of Traditional & Improved Jute, Potato Cropping Patterns, BJRI, Manikganj, CSRS, 1983-84. October 1984.	1
Saha, Jibhan Krishna (S.O.)	Socioeconomic Assessment of Improved Jute Production: Benchmark Survey Kanaipur, Faridpur, 1984. December, 1984.	2
Choudhury, S.S. (S.O.)	Preliminary Analysis of Livestock. Data from Dhaka & Kishoreganj District. CSRS. 1982-83. March 1984.	3

Workshop #2: January 17, 1985; BARC, Dhaka

Nabi, Nurun (S.O.)	Agroeconomic Analysis of Jute Production in Kalampur CSRS 1982-1983. March, 1984.	5
Islam, Nazrul (S.O.)	Income Analysis in the CSRS of the D-N-D-Project, 1983. May, 1984.	6
Karim, Rezaul (S.O.)	Agroeconomic Study of Country Bean Production. December, 1983.	4

Workshop #3: February 28, 1985; BARC, Dhaka

Rahman, Mustafizur (S.O.)	Income & Expenditure of Farmers in Jessore CSRS, 1982-83. July, 1984.	10
Karim, Rezaul (S.O.)	Partial Budget Analysis of Fertilizer & Cropping Pattern Trials at Hathazari, CSRS, 1982-83. March, 1985.	8

Saha, Ranjan Kumar, et al. (S.O.)	Farm Resources at Kalikapur CSRS, Ishurdi 1983-84. July, 1985.	7
Baksh, Elahi (S.O.)	Analysis of Farm Resources at Janakinathpur FSRS, Rangpur, July 1984. March, 1985.	13

Workshop #4: May 18, 1985

Alam, Shamsul (S.O.)	Fertilizer Price Analysis FSRS, Jamalpur, 1984/85.	11
Saha, Ranjan Kumar (S.O.)	Farm Income & Expenditure Behavior, Rabi Season, Kalikapur FSRS, 1983/84.	12
Choudhury, S.S., et al. (S.O.)	Income Analysis of Rural Households, FSRS, Kalampur, 1982/83. April, 1985.	9

Workshop #5: July 31, 1985

Siddique, Abu, et al.	Agroeconomic Analysis of CSR at Thakurgaon, 1982/84. July, 1985.	14

AGRICULTURAL RESEARCH PLANNING AND MANAGEMENT: A SHORT COURSE FOR PROFESSIONALS IN AGRICULTURAL RESEARCH AND DEVELOPMENT.

by
David Gibbon and Stephen Biggs

Introduction

Since 1982 a six week course for developing country research and extension staff has been run annually at the School of Development Studies, University of East Anglia,(UEA) Norwich, UK. The School has a multidisciplinary faculty, all of whom have regular, operational experience in developing countries in addition to teaching and research activities connected with undergraduate and graduate courses based at the University. Several faculty have extensive experience in working within national and international agricultural research institutions and programs. The authors have attempted to utilise this experience, together with that of senior staff from other institutions in the design and development of the course.

Rationale

Many national agricultural research programs are undergoing radical reorganisation following a reassessment of priorities, plans, and orientation. Much of the stimulus for this has come from the introduction of farming systems research and extension (FSR/E) as a major component of research programs or as a 'new approach' that all researchers and extension workers need to understand. The International Agricultural Research Centres (IARCs) and several major aid donors have played important roles in these changes and they have provided training funds for senior and middle level scientists to undertake short, medium, and longer term training at a variety of institutions both in-country and overseas. The Overseas Development Administration (ODA) in the UK has also supported training and reorientation for a number of its field staff in recent years.

A short course in Agricultural Research, Planning and Management for middle level professional staff was set up in 1982 at the University of East Anglia to provide training and an interdisciplinary environment for the exchange of ideas and experience on recent developments in agricultural research.

It was intended that such a course would fill an existing gap in training opportunities for middle level professional staff, those who had some years operational experience but who might have little knowledge of the rapidly expanding farming systems literature, both theoretical and case study materials. Both natural and social scientists might also benefit from comparative studies from elsewhere and new methodological skills.

There are clearly advantages and disadvantages of basing the course in England rather than in a region or country in the tropics. The main advantage of the location in England is that we have access to a very wide range of facilities, bibliographic materials and faculty experience. Also, bringing together people from different training and experience backgrounds in a stimulating environment away from their own work situation can be very productive for participants, course directors, and other contributors. There are obvious apparent disadvantages, such as the lack of direct environmental or local relevant research situations to study. However, the analysis of the UK research system has provided some valuable information, particularly on the subjects of policy, planning, organisation, and management of research systems. Also, many staff can only be released from their work for relatively short periods particularly where research systems have only limited manpower.

Objectives

The primary objective of the course is to review and analyse methods and techniques used in the planning, organisation and management of agricultural research systems in developing countries.

Other objectives include:

1. To develop the confidence and capacities of participants to plan and conduct research by analysing a range of problems drawn from their own experience.

2. To stimulate constructive discussion between participants and seminar leaders in order to develop an understanding of FSR/E perspectives in problem solving.

3. To provide a basic range of bibliographic and other materials that will be of use to participants in their own countries.

4. To establish links with participants and to support research planning and training activities in their own countries.

Participants

Participants have been mostly middle and senior level natural and social scientists drawn from research and extension divisions within Ministries of Agriculture in 14 countries. The countries of origin or operational experience were: Bangladesh, Nepal, India, Philippines, Brunei, Somalia, Ghana, Brazil, Yemen, Tanzania, Malaysia, Mexico, Zimbabwe, Colombia. We have also had five UK participants, both social and natural scientists with developing country experience, who were supported by the British Overseas Development Administration. One participant was supported by the Swedish International Development Agency and the rest were supported either by their own governments or by the Ford Foundation.We have attempted to have about 12 participants on the course and in general we have had that number confirmed in each year. Unfortunately, we have rarely had that number actually attend due to a variety of reasons that are discussed at the end of this paper.

Course Design

The course has been designed and directed by the authors who have both natural and social science training and experience. The course has evolved from their experience and from the invaluable interaction with colleagues, visiting speakers, and participants.

The course is built on three major themes:

1. Principles and procedures used in farming systems and on-farm research.

2. Methods and criteria for allocating scarce research resources in projects, programs, and national agricultural research systems.

3. Issues concerned with training researchers and with the management of agricultural research and extension in different cultural, institutional situations.

A mixture of lectures, seminars, paper writing, workshops, films, and visits to agricultural research institutions are used throughout the six-week period. A different topic is covered in each week:

1. Basic issues in planning agricultural research.
2. National and international agricultural research and development systems.
3. Farming systems and on-farm research.

4. Case studies of FSR/E and other agricultural and natural resource research.
5. Policy, resource allocation, organisation, and management of research.
6. Evaluation and training of research and extension.

The timetable is flexible enough to include additional topics suggested by participants and to include the presentation of papers by participants. While the course is running, participants are invited to social events - combined meetings with other short course participants, visits to places of local and historical interest, entertainments and informal gatherings with other members of the University. Attendance on these occasions is voluntary but they have proved to be essential and rewarding activities in the development of effective communication and understanding between participants and directors.

Materials and Methods

Some comment on each of the major course resources and components follows.

The principal resources for the course are the bibliography of books, reprints and reports (406 items) organised under the six main topic areas above, the papers provided by visiting speakers and UEA faculty and the materials brought by participants from their own countries. Additional materials are collected during field visits.

Lectures and seminars are usually planned with 45-50 minutes presentation followed by a further 45-50 minutes discussion. The bulk of the presentations are by members of Development Faculty but a significant number of speakers are drawn from research institutions in the UK and overseas who have particular expertise. Most of the visiting speakers have contributed to all the courses although each year a few new contributors appear. Invitations are extended to people who are travelling through the UK or who are on home leave.

The field trips are designed to give participants some insight into the management, organisation and structure of the UK agricultural research system. The major purpose of these visits is not to present a model of how research should be organised but to enable participants to discuss, with reference to a particular situation such issues as:

1. How priorities are established.
2. How research resources are allocated between competing demands.
3. Why institutional structures change.

4. What are the rules for professional recognition and promotion.

The field trips range from a visit to a local farm, to Rothamsted Research Station.

During the course, participants are expected to write one or more papers. One of these is about 4,000 words covering:

1. The present state of agricultural research (or part of it) in a particular country or region: and

2. Proposals for how the specific agricultural research discussed earlier might be improved.

Participants are asked to bring relevant materials to answer some of these questions when they travel to the UK. The papers are presented at the end of the course, discussed, and are then produced as a combined report by the School Publications Office. A list of papers appears in Appendix 1.

In addition, sessions in the course are devoted to: a "Green Revolution" simulation game, information searching and data analysis using micro computers and training in study skills.

Evaluation

At the end of the course an evaluation session is held. A check list of questions is provided - on course content and style, length, timing, administration, bibliography, field trips and visiting speakers. Participants are asked to comment either verbally or in writing or both. This discussion is recorded and then used to plan the following year's course.

Problems, Benefits and the Future

Inevitably there are always a number of problems associated with the running of a course of this nature.

Problems

Though we take care in advising and choosing appropriate participants, the end result is that we receive people with a wide range of abilities and sometimes very different expectations of the course. Some require very basic techniques and methods

training and others are more interested in conceptual, policy and planning issues. With a relatively small group this is not a difficult problem to overcome but it does mean that we have to be very flexible and accept any research or extension worker who has an adequate academic background and a strong recommendation from a sponsoring institution or agency.

Some problems arise over the uncertainty of participants arriving late (or not at all) for the course due to difficulties over funding or with government clearance. It is well known that many governments are becoming increasingly reluctant to grant permission for certain officers to travel abroad for short course training.

Benefits

Participants return home with a good understanding of the basic concepts of modern agricultural research approaches. They also have learned a range of methods and techniques for collecting, analysing and interpreting data and they have a knowledge of the organisation and management of research systems. They carry with them a substancial amount of literature which is often later used as the basis for training courses in their own countries.

The linkages development between former participants and faculty have been valuable in both directions and we now have good relationships with a number of professional staff within the same research system in several developing countries.

The Future

For the future we would hope that the course may continue to attract high calibre participants and that we can evolve the course content and orientation to suit changing needs and demands. We are increasingly involved in esearch evaluation and the advice on short courses in developing countries. We do not forsee any major changes to the basic structures of the UEA course, but we would like to make it more attractive to professional extentionists. We feel very strongly that there are still major barriers to effective communication between research and extension systems (partly exacerbated by separate structures and funding) and that extension personnel should have a greater involvement in all research activity, particularly in farming systems research. Equally, researchers must be more aware of how extension systems operate and what forms of support and involvement will be beneficial.

Acknowledgement

The authors would like to acknowledge the untiring help of assistants of the Overseas Development Groups - Ruth Grosvenor-Alsop, Jane Bartlett, Norma Meecham, Lesley Knight and Rosie Squires. Ten colleagues from the School and a number of regular visiting speakers have made the course very stimulating and rewarding and their help is greatly appreciated.

APPENDIX 1: PARTICIPANTS PAPERS (selection only)

1. Proposals for Farming Systems Research in Malaysia.

2. Agricultural Research Planning and Organisation in CIAT, Santa Cruz, Bolivia.

3. Development, Diffusion and Consequences of Destumping and Mechanisation in the Chane-Piray Colonisation Area of Santa Cruz, Bolivia.

4. The State of Agricultural Research Planning in Zimbabwe.

5. The Development of Agricultural Research in Somalia.

6. The Development of a Short Course on Farming Systems Research.

7. On-farm Research Planning for Rainfed Rice-Based Farming Systems in Two Different Agro-climatic Zones of West Bengal.

8. Agricultural Research in Bihar.

9. Contextual Imperatives of Agricultural Research Planning and Management in Uganda.

10. Understanding Processes of Development of Agricultural Research Capabilities: The Case of Uyole Agricultural Centre, Tanzania.

11. Nepal´s Agricultural Research System: Some Restructuring Issues.

12. The Improvement of the Present Research Budgeting and Project Proposal Systems in the Tanzanian Research Institute.

13. Agricultural Research for Development in Ghana: Overview of Institutional and Policy Considerations for the 1980´s.

14. PRO-RURAL Research Project: Constraints and Possible Solutions (Brazil).

15. The Agricultural Research Systems in India: Some Problems and Suggestions.

16. Strengthening Agricultural Research in the Kosi Hill Area, Nepal.

17. Institutional Growth of Agriculture in India.

18. Research on Cattle Production in the Yucatan Peninsula.

19. Crops Research and Planning and Implementation in Somalia.

20. On-farm Research in Rice Farming Systems in Orissa.

21. Research and Seed Multiplication Farms in Nepal.

22. Agricultural Research in Brunei.

23. An Assessment of the Provincial Technology Verification Team as Agents for Technology Development and Technology Transfer.

24. Effectiveness of Cropping Pattern Research to Upland Farmer Needs.

Training International and Domestic Students in Rapid Rural Appraisal: Farming Systems Research/Extension "Sondeo" Laboratory at Virginia Tech

John S. Caldwell, Angela Neilan, Eija Pehu, and Segu Zuhair

Background

In the 1960's, the focus of international development was on development of "packages" of technology for basic staple crops, especially rice and wheat, under relatively uniform conditions, often in irrigated areas. This approach was know as the "Green Revolution". In the 1970's, the focus shifted to approaches aimed at establishing research priorities among diverse mixes of crops and animals under widely varying conditions, often in upland, rainfed areas (Caldwell, 1984; Ferguson, 1983). By the early 1980's these more site-specific technology development approaches came to be known generally as "Farming Systems."

Today, Farming Systems Research/Extension (FSR/E) is being applied in development projects in countries with agroclimatic and socioeconomic conditions as different as Zambia in Africa (Hudgens, 1986) and the Philippines in Asia (Zuidema and Caldwell, 1985). Many of the international students who study in universities in the United States may return to positions where they will be involved in FSR/E. Domestic students entering international agriculture may also have opportunity in the future to work as counterparts with national program researchers in FSR/E projects in developing countries.

Increasing interest has also been evidenced within the United States in investigating the value of FSR/E as an additional tool for working with limited resource farms within the U.S. land grant university - Cooperative Extension system. The United States Department of Agriculture (USDA) has supported efforts to test FSR/E in several states, beginning in Florida in 1980 (Hildebrand, 1983; Swisher, 1984) and Virginia in 1981 (Caldwell et al., 1983; Caldwell et al., 1985a). These experiences were reported in a national conference on domestic FSR/E held at the University of Florida in September, 1984. Domestic students may thus also have opportunity to apply FSR/E in future work within the United States.

For the above reasons, in order to link international and domestic teaching, research, and extension, in 1982 a 3 credit-hour farming systems course was developed and taught in the Department of Horticulture at Virginia Tech. This course was then revised and taught as a 4 credit hour course in the 1984 fall quarter, in order to give more time for a laboratory designed to train students in rapid rural appraisal. This paper reports on the 1984 laboratory experience.

Rapid Rural Appraisal and the "Sondeo" in FSR/E

In initial FSR/E diagnosis, the objective is to establish research priorities from among all the crop and livestock activities common to the recommendation domain farm families. Diagnosis assesses interactions among those activities, between each activity and the household, and between each activity and markets, but the objective is not to quantify all the interactions of the farming system. This basic qualitative orientation of FSR/E diagnosis reflects lessons learned from attempts at applying comprehensive, quantitative farm management or baseline survey approaches for the identification of research priorities in FSR/E. The older approaches are time-consuming, expensive, and usually require access to computers (or large numbers of tabulator personnel). Their most critical drawback is that by the time data for establishing research priorities are available from such surveys, usually several seasons during which testing could have been done have been lost. By then, too, needs and constraints may have changed, and real priorities would now be different from those suggested by the data (Beebe, 1985; Chambers, 1980).

The alternative approach utilized by FSR/E is rapid rural appraisal. This involves an informal survey conducted by a multidisciplinary team. This assures that comprehensiveness is maintained, since each team member will tend to focus on the aspect of the system that falls in the province of his or her discipline. The team approach also assures a balanced assessment, since the whole team must reach a common consensus or priorities. Informal interview techniques reduce time, expense, and turn-around time. (Beebe, 1985; Chambers, 1980; Rhoades, 1982).

There are several variations of rapid rural appraisal in the FSR/E literature. One of the most widely applied is the "sondeo" technique, developed at the Instituto de Ciencia y Tecnologia Agricolas (ICTA) in Guatemala (Beebe, 1985; Shaner et al., 1982). The word "sondeo" comes from the Spanish verb sondear, to "sound out." This technique was modified for use in the 1984 course laboratory.

Organization of Laboratory "Sondeo" Teams

Fifteen students in the 1984 class participated in the laboratory exercises. The students were divided into four teams of three to four members each. Each team was further subdivided into two interview pairs of two persons each (the instructor functioned as the second interview pair member for the team with only three students).

Students were assigned to teams and interview pairs within teams so that balance was simultaneously achieved among disciplines, nationality (international vs. domestic), and gender (Table 1). These principles and methods of team organization

drew largely from previous experience in organizing "sondeo" simulations in a Farming Systems Support Project (FSSP) sponsored workshop for U.S. and international participants at Virginia Tech in August 1983 and an FSSP sponsored Gambia/West Africa Farming Systems Workshop involving participants from West African countries, the United States, Britain, and France, held in The Gambia, West Africa, in March 1984 (Poats, 1984).

In the assignment by discipline, each student was asked to focus on those aspects of the farming system most closely related to that student's discipline. Where there was more than one student on a team of the same discipline, assignment also took into account the student's minor or previous experience.

In the assignment by nationality, the students were advised that in the "sondeo" of local U.S. farmers, each would have a chance to function in the role opposite of what they would function in a developing country. That is, the domestic students, who in the future might be counterparts in a developing country, here served as host country nationals with greater familiarity of local conditions. On the other hand, the international students, who in the future would function in the host country national role, here had the opportunity to serve as counterparts and assess a less familiar situation from a more neutral, objective perspective. It was found that a team consisting of members of different cultural backgrounds was a definite asset for the team. It was observed that the farmers were less hesitant to answer the questions asked by international students. Farm family members appeared to feel less of a threat. Within the team it was enriching to learn the different views and emphases of fellow team members.

The students also had an opportunity to function in the reverse of the above roles in another laboratory project involving a review of secondary data (such as one would do at the beginning of design team work in a new project) for the country of one of the international team members.

Gender of the interviewer can affect the responses of farm family members, particularly regarding the distribution of labor and assessment of goals and problems, in both domestic U.S. and international contexts (Rojas, 1983). All female interview teams are one technique for eliciting more accurate information from female farmers or farm family members. In the class, an all female interview team was therefore used in one team. Since there were only four female students in the class, two of the other teams had only one female team member, and the fourth team had none.

"Sondeo" Locations and Farm Families

In the laboratory exercise, farm families were identified through Extension and informal faculty networks in two counties adjacent to the university. Farms in both counties were within one hour driving distance from the campue. The four teams were divided into two laboratory sections, with two teams in each

section, so one team in each section was given one county, and the other team was given the other county (Table 1). This enabled students in each section to compare the two counties. Each team was given instructions on where to locate secondary information on their county, including the telephone numbers of the county Extension offices.

Initial contact was made by the instructor or the laboratory assistant. After explanation of objectives to a member of the family, if the family member agreed to participate, one member of each interview pair then contacted the family to explain again the objectives of their visit, confirm willingness to participate, and establish a mutually convenient time for a one to two hour visit. Each interview pair was asked to interview two families during a two week period.

One interview pair was asked to interview a family without a telephone. After several unsuccessful attempts to locate that family, they instead interviewed members of two families selling produce at the local farmers' market.

Team Building and Interview Techniques

Team assignments were made in the first laboratory session. Prior to the actual "sondeo" exercise, the students had opportunities to work as a team in three other in-class exercises, as well as in developing the country project reports referred to earlier. These activities were all aimed at team building, a critical element in successful multidisciplinary team functioning in the field. However, due to the different levels of professional development of the team members, there were great differences in the conceptual understandings of the problems, which occasionally led to difficulties in communication. It was further observed that specialization in higher education seems to indoctrinate people and make them very defensive of their own disciplines. Thus, in the training of team members for team building, mutual respect and willingness to work together should be emphasized more.

There are two schools of thought regarding interview technique for rapid rural appraisal in the FSR/E literature. One school of thought utilizes a "blank mind" technique, in which the interviewers do not formulate prior hypotheses, do not use formal questionnaires or even plan a mental framework of topics for the interview, and do not take notes during the interview (but record immediately thereafter). This school of thought reflects principles and methods used in anthropological research in agricultural communities where frequently not enough is known prior to the survey to make hypotheses that are consistent with the internal mental framework of needs and priorities of the farm family members. Prior hypotheses in such conditions tend to reflect preconceptions of the interviewers. The ICTA "sondeo" methodology uses this type of interview technique (Shaner et al., 1982).

The other school of thought utilizes an interview guide technique. With this technique, a mental framework of topics is developed by the team beforehand. The topics are not read as in a formal questionnaire, however, and do not have to be followed in a pre-determined sequence. Questions remain open-ended, rather than asking respondents to select from a set of predetermined choices. Notes may or may not be taken during the interview, depending on the interviewer's judgement in each interview. This technique retains informality and openness to information not anticipated by the interviewers prior to the interview, while increasing comparability of interviews and assuring that key areas are included by using the mental "checklist" of topics. Patton (1980) outlines advantages, disadvantages, and techniques associated with the "blank mind" (or conversational), interview guide, standardized open-ended, and closed questionnaire approaches.

In the course, a modification of the open-ended interview guide approach was used, based on previous experience in conducting "sondeos" in Southwest Virginia (Caldwell et al., 1985c). Various techniques were used to train the students in this approach prior to the actual family visits. A set of slides outlining the approach was shown, followed by a videotape of "sondeo" interviews in Southwest Virginia (Caldwell et al., 1985b). Students then had an opportunity to practice interviewing the laboratory assistant, and receive feedback on interview technique from her. The laboratory assistant was formerly an Extension agent in one of the "sondeo" counties. Each team was also given a copy of a manual with sample interview guide formats, farm reports, and content analysis procedures. This manual was also based on earlier work in Southwest Virginia (Rojas, 1984).

In questioning technique training, emphasis was placed on two points. One was the asking of truly "open-ended" questions. This is particularly important for horticulturalists and other biological scientists. Research procedures in biological science are based on establishing a null hypothesis and then testing that hypothesis. In eliciting responses from farm family members, biological scientists tend, therefore, to phrase questions to test their hypotheses. For example, in the Gambia, in one instance when a horticulturist was observing a woman gathering peanuts left in a field after the main harvest, he formulated the hypothesis that she might have to divide what she gathered with the landowner. The horticulturist thus asked a Gambian researcher in the jeep, "Does she share the peanuts she is gathering with the landowner?" Later, an anthropologist team member pointed out that this type of question closed the possibility of determining what was the most important disposition of the peanut. The question should have been phrased, "How does she use the peanut she is gathering?" This would have allowed the Gambian researcher to express his knowledge and perceptions of the farmer's disposition of the peanut.

This technique is conceptually analogous to a preliminary experiment, such as initial varietal or pesticide screening, where we do not know enough to specify single degree of freedom hypotheses, but allow comparisons and future hypotheses to emerge from the data using a multiple comparison procedure. Based on what we learn from the initial experiment, we may then design a follow-up experiment to test specific hypotheses about specific treatments or factors. Similarly, in FSR/E diagnosis, the "sondeo" may be followed by a formal, quantitative survey on selected aspects of what is learned from the "sondeo," such as in the verification formal surveys used by CIMMYT (Byerlee et al, 1980).

The second point of emphasis in the questioning technique training was on differences in gender of the respondent or the interviewer. For example, male respondents will frequently say "I planted broccoli," whereas women will say, We planted broccoli." Women may also say, "I helped with the seedbed," even if they were really in charge of planting it. This type of a difference in language use was frequently observed in the "sondeo" interviews conducted by the students. It was further noted that differences in language use were present in both the traditional small farmers as well as the more progressive "hippie" farmers, indicating the presence of a sex role bias at the attitudinal level in spite of the apparent difference in the "progressiveness" of the two groups. This finding is supported by a recent study by Kirjavainen (1984). The usage of pronoun ratios might be a useful tool for the social scientist in "quantifying" attitudes and should also be used in the different stages of FSR/E, because these differences in language use can mask potential users of new techniques, or even interest in starting new activities, such as blueberries or raspberries (Rojas, 1983; Rojas, 1984).

Team Processing, Reporting, and Use of Data

Each team prepared two types of reports. The first was a written report on one of the farms they had visited. Since each interview pair visited two farms, each team member was able to write about a unique farm.

Each written report was further divided into two sections. The first section was a description of the farm, following the format of topic areas of the interview guide developed by the team. The format suggested in the manual (Rojas, 1984) included sub-sections on crops, animals, the household, and family goals and needs. Figure 1 shows a structural model of one farm, depicting farm and off-farm activities and their interactions. The structural model, a technique developed by McDowell and Hildebrand (1980), is an aid to identifying "leverage points," points in the system at which innovations can be proposed which will increase productivity and which the farm family will be able and willing to adopt (Franzel, 1984).

The second section of each written report was a discussion of team interaction, focusing on how the team member's discipline contributed to team analysis of the farms, what hypotheses formulated by the team member were reinforced by information obtained by other team members, and what hypotheses the team member changed based on information obtained by other team members.

The second type of report was an oral report by the team to the other team in their laboratory section. Each team had approximately 50 minutes to present their oral report. The teams were cautioned that the exercise was only a simulation, and that four farms were an inadequate sample on which to establish recommendation domains (Harrington and Tripp, 1984) and determine a research agenda for the county. The teams were thus asked first to identify what additional infomation they would seek to obtain if they could interview additional farm families. For example, one team identified a need for more information on the long-term effects of Christmas tree production. They were also asked to suggest preliminary hypotheses about recommendation domains and possible interventions (changes in practices which could be tested through on-farm trials) for farms of the types they observed. The same team identified soil erosion control in Christmas tree production as a possible intervention. Another team grouped the farm families they visited by their priority problems, and found that marketing was a priority problem for half of the farms the team collectively had visited. Following the ICTA procedure (Shaner et al., 1982), the teams were advised that the objective was to reach a consensus that each team member would be able to explain and support.

Value of the Laboratory

The laboratory was valuable to the students as a learning experience, as evidenced by both qualitative and quantitative assessment. Both the written discussion on team interaction and the presentations and discussions indicated that the students developed significant capabilities in several areas. These included:

(1) the ability to work with other disciplines towards a common objective;
(2) the ability to appreciate the perspective of the outside counterpart from the perspective of a host country national, and vice-versa;
(3) the ability to recognize the multiple roles of fram family members in managing a family farm.

In student evaluations of the degree of their achievement of 15 learning objectives at the end of the course, students gave their highest achievement rating (4.4 on a scale of 1 to 5) to the objective of proposing appropriate priate procedures for data collection from a farming system. They gave their third highest rating (4.2) to the objective of using one's own discipline to serve commonly agreed upon team objectives. These quantitive

indicators of capabilities confirm the qualitative assessment of capabilities by the instructor based on observation of the oral reports, comments by team members in the written discussion on team interaction, and comprehensiveness of the written reports, including use of structural models.

Several changes could be made to strengthen the value of the laboratory as a learning experience. First, each oral report should include an introductory section summarizing the secondary data obtained by the team prior to the actual farm visits. The importance of taking advantage of relevant secondary data has been stressed on a recent review (Beebe, 1985).

Each oral report should also include a conclusions section following the body of the report. The body of the report summarizes the description of the farming systems, including possible groupings, while the conclusions outline the team's assessment of where additional information is needed and what interventions could be tested.

Second, the laboratory provides an excellent opportunity for students to develop oral presentation skills. Pointers on overhead preparation, format, and delivery should be given as part of the instructions, together with examples of structural models, crop calendars, and charts showing gender disaggregation of productive activities. Students might also evaluate each other's delivery, providing feedback for improvement.

Finally, in a real FSR/E project, it is essential to continue the interactive process of dialog with farm family members, by discussing with them the team's analysis and proposals for interventions. Given adequate time in the laboratory, and especially if the laboratory were linked to actual on-farm trial design and implementation, a feedback session could also be included, where each team presented their conclusions to a group of farm families and research and extension personnel who would be involved in trials to follow. Students could be given the opportunity to do follow-up independent study on on-farm trial and design in cooperation with research and extension personnel.

In carrying out the "sondeos," students also need to be alert to the possibility that their visits may generate expectations on the part of the farm families. Students should be prepared to explain the objectives and limits of the exercise. On the other hand, even if the laboratory is not linked to follow-up on-farm trails, the students should also be prepared to give names and telephone members of appropriate research and extension personnel whom family members can contact if they have questions beyond the capabilities of the students.

In addition to its value as a learning experience for the students, "sondeo" laboratories could also have value as a more formal part of adaptive research and extension.

The multidisciplinary team approach to asessment of farm family needs, in fact, has antecedents in earlier programs in the U.S. land grant university-Cooperative Extension system that focused on small farms. In the 1960's the Tennessee Valley Authority sponsored rapid rural adjustment program utilized teams of agricultural economists, soil scientists, and animal scientists to develop farm management plans and identify farms to serve as model farms for those plans (Moore, 1972). The Balanced Farming program in Missouri, dating back to the 1940's, also utilized a multidisciplinary approach linking agricultural economics, soil, crop, and animal sciences, and home economics to develop farm improvement plans for individual farms (Hagan, 1984). Another program simular to the Missouri program was the Farm and Home Development Program, which began in Kentucky in the early 1950's but was extended nationally in the late 1950's and early 1960's (Johnson, 1982).

The above programs were largely abandoned or deemphasized after the 1960's, however, for number of reasons. One reason was increasing specialization of both disciplines and larger farms, coupled with a focus on maximizing production and profits from individual specialized enterprises. Interest declined in research and extension efforts focusing on achieving an optimum balance among diversified enterprises while minimizing risk from each enterprise to the farm household (Johnson, 1982).

During the intervening period after the decline of domestic programs that utilized a multidisciplinary approach, FSR/E procedures were developed outside the United States. While the diagnostic techniques for rapid rural appraisal of both the earlier U.S. programs and the FSR/E approach have similarities, there are differences in the steps that follow. The earlier U.S. programs were more prescriptive, and often sought to establish model farms or model farm plans (Moore, 1972). An assumption was that researchers knew what was best for the farm family members. On the other hand, FSR/E design and testing are based on the assumption that appropriate technology must first be developed and tested before extension efforts are possible. Researchers and extension personnel bring outside knowledge that is combined with farm family member experience and knowledge. Procedures for the statistical and economic analysis of trials replicated across farms have been developed by international centers and national programs (Hammerton and Lauckner, 1984; Hildebrand and Poey, 1985; Perrin et al., 1979).

As discussed at the start of this paper, the USDA has supported several efforts to apply FSR/E within the U. S. land grant university - Cooperative Extension system. This interest reflects both the above history of multidisciplinary work within the United States, and the contributions that the on-farm trial procedures developed by FSR/E practitioners outside the United States could make to the U. S. research and extension system.

In an era of reduced real support for travel, however, the team assessment approach is probably too expensive for faculty specialists to carry out today on a continued basis throughout a state. Ultimately, if FSR/E to be of value within the U.S. land grant university-Cooperative Extension system, Extension districts with numbers of limited resource farms great enough to justify special efforts targeted at that clientele need to be able to apply FSR/E themselves. Having all students in agriculture and home economics disciplines participate in a "sondeo" laboratory would be one way to help achieve this. The laboratory would provide an opportunity to train both the persons who later might become district or county Extension staff, as well as persons who later might serve as university or private sector specialists. At the same time, "sondeo" laboratories conducted with larger members of students and rotated among counties could serve as a way to provide outside multidisciplinary assessment of research needs in each county. The laboratory could also be followed by independent study on farm trial design and analysis, providing an opportunity for research and extension personnel in the United States to become more familiar with and apply appropriate on-farm trial procedures from the world-wide FSR/E literature, through their work with the students. Finally, by involving international students in the laboratories, not only would the international students have an opportunity to learn FSR/E procedures that they might later apply in their own countries, but also domestic students and farm families would have an opportunity to learn from the international students and increase their ability to participate in the broader world community.

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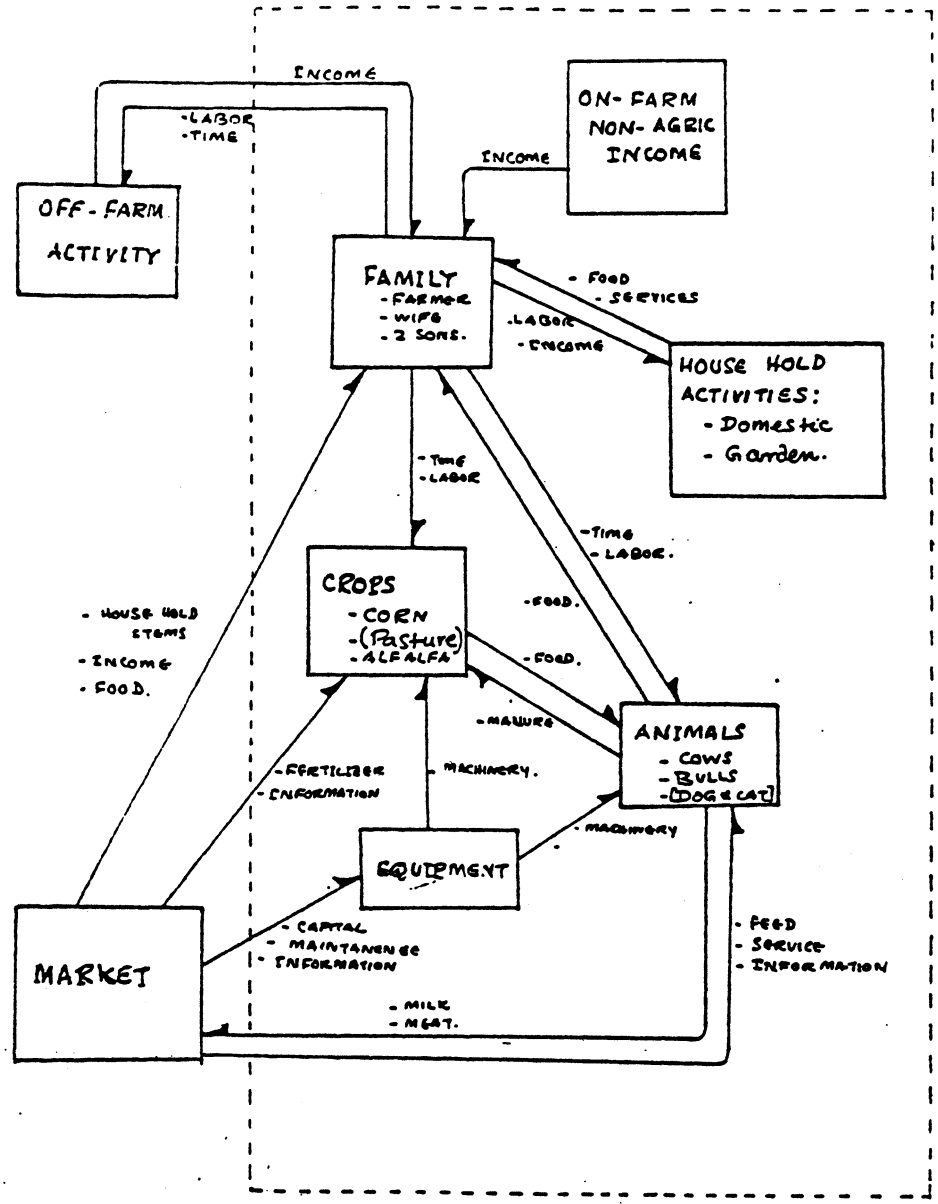
Table 1: Assignment of sondeo laboratory participants to country teams and interview pairs to achieve discipline, nationality, and gender balance.

Country Team (County)	Interview Pair	Discipline		Nationality		Gender	
		Agriculture Sciences	Social Sciences	International	United States	Female	Male
Zimbabwe (GC)	1	Horticulture	Sociology	1	1		2
	2	Agronomy	Agricultural Economics	1	1		1
Sri Lanka (F)	1	Horticulture	Agricultural Economics		2	1	1
	2	Agronomy	Agricultural Economics	1	1		2
Camerouns (GC)	1	Agronomy	Agricultural Economics		2		2
	2	Horticulture Horticulture		1	1		2
Kenya (F)	1	Horticulture	Regional Planning	1	1		2
	2	Horticulture Agronomy		1	1	2	
Total				6	10	4	12



COMPONENT INTERACTIONS

Figure 1: Example of a Structural Model of a Southwest Virginia Farm Presented in a Student's Report

DIAGNOSIS

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THE "DIAGNOSTIC PHASE" OF FARMING SYSTEMS RESEARCH IN AGRICULTURAL PLANNING - A CASE STUDY FROM INDONESIA

C. D. S. Bartlett and Sultoni Arifin

THE APPROACH

The main job of FSR is to get relevant micro-level information on the farm and household for use in planning the allocation of government resources by research planners or by other agricultural planners. In this paper, we describe a method we used for planning the allocation of government resources to a project in Java. We then go on to identify what farm level information was needed for this exercise and describe how it was collected and used.

PLANNING

The authors were given the task of suggesting improvements for an on-going project to maintain long-term agricultural production in the upland areas of a river basin in Java. We decided to approach the task as a re-planning exercise based on a simple procedure which:

1. identifies problems at the national, regional, and household levels which may be solved by agricultural production changes. A selection is made among these problems, with identification of the main causes for the selected problems;

2. identifies, in the following steps, methods by which the government may help farmers to implement production changes which could solve the problems:

   a) Production changes are suggested which may be able to solve the selected problems;

   b) Problems farmers may have with implementing these production changes are identified;

   c) Solutions to these problems are suggested in the form of:

      i. alterations to the production changes;

      ii. projects to provide services to solve these problems.

   d) Problems with implementing these projects are identified;

   e) Policy or program changes are suggested to solve these problems;

   f) Farmers' selection of production changes is made possible by projects and their associated policy and program changes are

identified.

3. makes a selection among alternative projects, together with their associated policy and program changes, on the basis of a comparison of:

   a) direct costs relative to problems solved;

   b) interrelationships between proposed projects.

This method is based on an iterative sequence of identification of problems, solutions, and problems with the solutions. It is suited to helping governments decide how to allocate their resources to the private sector of the economy.

THE ANALYSIS

The Problem and its Cause

The problem which the project was designed to solve was erosion and the decline of agricultural productivity in an area of Java. We could have made a review of national and regional plans, together with identification of farm household consumption problems, and then made an assessment of the importance of the problem of erosion relative to other problems. We omitted this review since there was no possibility that our work would change the overall objective of the project.

Evidence was available for Java as a whole that the most serious cause of erosion was exposure of bare soil to the heavy rainfall of the area. The major crop which left soil bare for the longest during the rains was sole cropped cassava (Hamer, 1981).

Suggested Production Changes

Project crop and soil scientists had made recommendations for modifications in the farming practices which would reduce the exposure of bare, sloping soil surfaces to rain. On slopes of less than 50%, they recommended bench terracing on the contour, together with waterways to channel the water off the land and planting grass on the terrace risers. Sheep and goats should be kept in stalls and fed the cut grass. A two- or three-season sequence of crops should be grown, starting with upland rice/maize at the beginning of the rains and followed by a legume/maize mixture and then perhaps by cowpeas in the dry season. This crop sequence should replace the widely grown sole cropped cassava. Slopes greater than 50% should not be terraced or planted with annual crops but with trees.

Problems with Recommendations

We found, by means of a survey, that a number of these practices had been widely adopted by the project farmers on their own land. These practices obviously posed no problems to the farmers of the area, but we found that

other practices had been less widely adopted: ridge on terrace lip, improved grass on terrace riser, waterways, change in cropping patterns, and animal ownership. These practices appeared to pose problems for the farmers. We then tried to identify the problems farmers had with the adoption of these latter recommended practices.

We identified these problems by developing and examining hypotheses. We started with basic hypotheses that the recommended changes would be difficult for the farmer to implement since they:

- lacked the extra resources needed;
- needed outputs which would be reduced;
- could not obtain the required extra inputs;
- could not use or sell the extra output produced;
- would have technical problems with the new methods, and
- lacked the required knowledge.

The main instrument we used for examination of these hypotheses was a single formal (using a questionnaire) survey of a sample of farmers who suffered from the problem of erosion.

Resources and Output

Changes. First, we made qualitative estimates of the changes in resource use and in output which would result from the change from sole cropped cassava to the recommended practices. Cassava production requires most labor for harvesting, which occurs between August and December. The recommended practices, by contrast, need labor for terracing in July or August, labor for planting in October, February, and May, and for harvesting in January, April, and June/July. Adoption of the recommended cropping patterns would reduce labor requirements between August and December but increase them in various other seasons.

Cassava produces cash income between August and December and requires little cash input. The recommended cropping patterns would need substantial cash inputs in September/October and in February/March. Income would be received in February and in June. The overall result of adoption of the recommended practices would be an increased cash deficit in September/October. Most cassava is eaten between August and December, while the recommended crops are harvested and may be consumed in the other half of the year.

Scarcities. In order to identify whether these changes in resource use and in output were likely to be a problem to farmers, we next determined what scarcities of farm inputs and of household requirements farm households suffered. Questions were directed to farmers about the type of land that they needed and the timing of scarcities of cash, labor, and food.

Determination of important scarcities was made by asking the farmer a series of questions on relative scarcities such as:

- whether farmers normally experienced scarcities of each input and output;
- which input or output they would most like to receive more of;
- whether, if one input was increased, increased quantities of others would be needed to complement it;
- how extra inputs or outputs would be used, and
- reasons for fallowing land.

We attempted to identify scarce resources which had a particularly high opportunity cost to the farmer by determining whether farmers had alternative non-farm uses for each resource. We also determined whether each scarce resource was essential for the farmers' strategies to solve another problem. For this purpose, we identified farmers' basic strategies for solving each of their main scarcities and the scarce resources needed to effect these strategies. Farmers alleviate the September/October labor shortage by hiring labor, for which scarce cash is needed. Cash in September/October thus has a particularly high opportunity cost to farmers as it is needed for the alleviation of another scarcity.

The main scarcity we identified by means of the above analysis was a shortage of irrigated rice land. Next in importance came a seasonal shortage of cash between September and December when cash is needed for hiring labor and for purchasing inputs for the first season crop. Labor at this time is scarce, as it is needed for cultivation of land at the beginning of the rains and also for the harvest of cassava. Cassava harvest helps to solve the cash scarcity at this time, as well as the food scarcity suffered by about half the farmers. The most critical period of the year for most farmers is September and October, when labor and cash are scarcest. This critical period is extended into November and December by continuing shortages of cash for many farmers and the beginning of food shortages for others.

Problems Identified. Labor problems may actually be alleviated by adoption of the recommended cropping practices. Terracing of the land will be inhibited by lack of labor only if large areas must be completed quickly. The scarcity of cash in September/October is likely to be a problem for farmers wanting to invest in inputs for the recommended rice/maize crop in the first season. Food supply problems are unlikely to be exacerbated by the adoption of the recommended cropping patterns.

Inputs

In order to implement the recommended practices, farmers need more fertilizer and pesticides, improved seed for upland rice, maize and legumes, seedlings for various tree crops, and improved grasses. There appears to be

no problem with the availability of any of these inputs in the project area as a whole and few farmers found unavailability of these inputs to be a problem. Some doubts were expressed, however, about the quality of the certified seed offered for sale.

Marketing and Processing

The production changes recommended by the project would produce extra quantities of rice, maize, legumes, and various tree crop products. With the possible exception of first season maize (which may alleviate a December food shortage for some farmers), these crops are unlikely to be especially valuable to farmers for consumption, and most of the additional output will have to be sold. We found that few farmers experienced problems in selling maize, rice, or legumes. Some farmers in the more remote areas found difficulty in marketing some tree crop products because of transportation, rather than marketing, problems.

Technical Production Problems

We developed hypotheses on what technical problems, affecting the level or variability of production, farmers might have with the recommended practices. The main possible technical problems with the change from sole cropped cassava to an upland rice/maize and legume/maize sequence is that the new crops would require more nutrients and may suffer more from pests and diseases. The new crops may also be more sensitive to the level and timing of rainfall, and there may be problems due to the several crops competing for various growth factors. The main technical problem with bench terraces, when they are constructed according to plan, is that they are unstable on certain soil types. Also, on shallow soils, large amounts of subsoil may be turned up and reduce the fertility of the soil.

Among these problems, the main ones identified by farmers in a survey were pests and diseases of small ruminants, coconut, clove, upland rice, and legumes. Examination of soil survey data, together with project experience, revealed that some soils in the project area would be unstable when terraced. In other areas, thin topsoils overlie solid clay.

We invited the relevant natural scientists to further specify causes of the pest and disease problems identified by farmers.

Knowledge Problems

A number of the demonstrated terracing practices and the first season cropping practices were adopted by the farmers in the project area, but not by farmers outside that area. Adoption appeared to have been the result of the knowledge imparted by the project, and the failure of farmers outside the project to adopt appeared to have been the result of lack of knowledge. The keeping of small ruminants and the planting of trees, however, appeared to have been unaffected by demonstrations of these enterprises given by the project.

Summary of Farmers' Problems with Recommendations

The adoption of the recommended practices appeared to pose the following major problems to farmers:

- Cash for first season crop inputs;
- Supply of good quality seeds;
- Pests and diseases of small ruminants, coconut, clove, rice, and legumes;
- Reduction in fertility of some shallow soils;
- Lack of knowledge of some terracing and cropping practices, and
- Lack of transport in some areas.

More work was needed by natural scientists to identify the types of pests and diseases which were most destructive. These questions were referred to the relevant specialists.

SOLUTION SUGGESTIONS

The project at the moment consists of demonstration plots on farmers' land. These areas are given intensive extension attention, subsidies, and other help to ensure that the recommended practices are used. Their main function is to improve the farmers' knowledge of the recommended practices. The foregoing analysis indicated that lack of knowledge of some of the recommended practices was a cause of failure of the farmers to use some of the practices. Demonstration of these practices should continue. The knowledge of small ruminants and of tree cropping imparted by the project did not influence the adoption of these enterprises. Demonstration of these enterprises might be discontinued.

The analysis also indicated that farmers had important problems, other than knowledge, with adoption of the recommended practices. Identification of suitable changes in recommended practices, and in the services provided to farmers to help them deal with these problems, required questions to specialists. We sought from conservationists suggestions on soil conservation methods which might reduce the productivity of thin clay soils less than does bench terracing. Solutions for the pest and disease problems could be suggested by entomologists and pathologists only after full identification of the causes of the problems. The problem of lack of cash to finance the inputs for the first season crops might be solved by a number of alternative measures:

- Changes in the recommended practices so that the level of purchased inputs could be reduced. Suggestions on such practices were sought from crop scientists.

- Growing tree or field crops which can be harvested and sold in August or September. Tree and field crop specialists were asked to suggest such crops which might be grown in the project area.

- Provision of seasonal credit. A credit specialist was asked to suggest how seasonal credit to farmers might be improved.

The possibility of improving roads in the remoter parts of the project area needed to be investigated by public works engineers. Specialists needed to investigate problems with the seed supply system and to suggest ways to solve these problems.

In order to answer these questions, the specialists needed to carry out a variety of investigations, tests, and adaptive research to identify: 1) solutions to pest and disease problems; 2) first season cropping practices requiring a lower level of purchased inputs; 3) crops which may be harvested in August or September, and 4) soil conservation methods suited to thin soils. Studies should be made to examine the feasibility of: 1) road improvements; 2) improvements in the seed supply system, and 3) improvements in the supply of seasonal credit.

When the tests and adaptive research have been completed, the revised recommendations should be resubmitted to the analysis described above for the purpose of identifying what problems they might pose to farmers. This process should indicate what services can help farmers to implement the revised recommendations. The feasibility of projects to supply these services may then be examined. If there are problems with implementing these projects, then policy or program changes may be suggested to solve these problems and the feasibility of these changes examined.

Further Possible Planning Steps

When the above analyses have been completed, a selection could, in principle, be made between alternative changes in production practices, together with the project components which will provide services, to enable farmers to adopt the practices and any program and policy changes which may be needed for the implementation of these projects. Farmers will need to select between practices which compete for any single resource which is scarce. They are likely to select the change in practice which gives them the greatest added gross margin per unit of added scarce resource. After this selection, the government would have to assess how much each alternative set of projects, together with complementary program and policy changes, will cost it and how each alternative would interact with other projects in the region.

DISCUSSION

In this work, we used a procedure for planning the allocation of government resources to a sector of the economy which is mainly private. This planning procedure is based on the premise that government's role in such a sector is to solve producers' problems.

Farm level information is required at two stages in this planning process:

- To identify farm household problems which may need to be solved, and

- To identify problems which farmers may have with recommended changes in production.

The second set of farm level information is essential for the completion of the planning sequence. Without knowing what problems farmers have with what we want them to do, we cannot design adequate programs to help them make those changes. FSR/E, and particularly the techniques of the "diagnostic phase," appear to be highly suited to providing information for these purposes.

The main focus of the work of the "diagnostic phase" of FSR/E is in identifying problems farmers might have with recommended practices. We proposed that the essential process used to identify these problems is the development and testing of hypotheses on problems farmers might have with the proposed changes. In our work in Java, we examined a general set of hypotheses on these problems. For the initial testing of our general hypotheses, we used a simple farm household model which identified scarcities of inputs and outputs to the farm household in relative terms. In developing this simple picture of the farm household, we found that a fairly standardized set of basic information was needed and used a preliminary formal survey for its collection.

Solutions to the problems farmers have with the recommended production changes are suggested, either in the form of changes in these recommendations or in the form of new services to reduce the problems farmers have with these recommendations. Research by natural scientists may be required for the design or adaptation of production practices for any changed recommendations. These changed practices are then reexamined for problems farmers might have with using them in an "iterative process." Additional services needed by farmers form the basis of projects.

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A CLASSIFICATION OF FARMING SYSTEMS, PRELIMINARY TO AN EXTENSION PROGRAM. A METHODOLOGY

Alain Capillon

INTRODUCTION

Studies made of farms within the same vicinity in France show that farmers do not have similar methods of cropping or breeding. In this diversity, you can see the different responses made by the farmers to the same technical advice, given the same natural environment. The existence of a great diversity of farming methods within the same region and the decision of politicians to keep a sizeable agricultural population in France has meant that some research on this question has taken place over the past fifteen years.

A number of study groups, especially those formed in 1979 by *Departement de Recherches sur les Systemes Agraires et le Developpement*, have studied how farmers make decisions. Their interest is in understanding what happens in the minds of farmers when they make technical choices: their objectives, constraints, and possibilities that affect the management of their farms.

Many study groups endeavor to understand such farms as systems controlled by the objectives of the farmers and their families and aim to comprehend the functioning of such farming systems (INRA-ENSSAA, 1973; Capillon, Fleury, Sebillotte, 1973; Osty, 1978; Bourgeois, Sebillotte, 1978; Duru, et al., 1979; Capillon, Sebillotte, 1980; Bonnemaire, Deffontaines, Osty, 1980; Petit, 1981; Gibon, 1981). The above studies were conducted both on individual farms and on the farms making up a whole region, mostly centering on the latter.

Originally, the unit SAD-INA/PG was mostly composed of research-teachers working under the direction of Professor Sebillotte, who holds the Chair of Agronomy at *Institut National Agronomique Paris-Grignon*. Each year since 1970, they studied a different region in France. The result of these works was a regional method of approach. It at once became evident to the agronomists in the group that the technical choices made by farmers were governed by other things than the natural environment or production processes. The professional pride of the farmer and the family's desire for a better life also intervened. Consequently, any technical judgment cannot be made simply by taking into account the farming possibilities and restraints, but must also include a total system approach (Sebillotte, 1974; 1978a). Thus, when a change in farming methods is suggested, it is important to prove that the farmer is capable of effecting it and that the change will be beneficial. More often than not, the extension officer will try to obtain the maximum yield without verifying that this is within the farmer's capability.

Does this mean that we can only give individual advice? If so, then we will only be able to reach a small number of farmers. I think not. One

solution would be to identify farm types in which each farm functioned in a similar manner, in which case a similar level of advice would be appropriate.

A CLASSIFICATION OF FARMING SYSTEMS - METHODOLOGY

A farm is looked upon as a goal-orientated system: farmers carry out land use, crop, and livestock production with the purpose of reaching their own objectives (such as profits, standard of living, improvement of working conditions, farm future, etc.).

Farm studies aim at understanding the decision-making process of the farmers at the time of the survey and previously, so we give prominence to farm functioning and history. This classification proceeds by bringing together a number of farms within some homogeneous types as regards both farmers' choice of various activities (crop, livestock production, inputs they received, and marketing activities) and reasons for these choices (farmers-goals, changing circumstances in the farm environment, natural constraints, etc.). These are the farm functioning types. The comparison deals with the production process and its repercussion on farm outputs or income. This classification is made not only for technical or economic results, but also for the production method. Afterwards, this enables a comparison of results within a given type in order to analyze the causes of variations and to come to some conclusions as to the best actions to implement.

Figure 1 shows the different phases in the methodological approach. Here, we will deal with three specific phases of this methodology: sampling method, farm study, and farming systems classification.

Sampling Method

It is absolutely necessary to start off by conducting a survey of the farms in the given region. Neither the National nor the Regional Statistical Surveys give sufficient information as regards productions and management; for instance, as regards cropping systems. On the one hand, it is necessary to study a lot of farms in order to find significant enough differences which can be used as an objective basis to think about. On the other hand, comparison of farms makes sense if the environment does not determine too important differences between farms due to great variations in natural conditions or economic organization. Thus, we have to limit our study to an area where natural conditions and the socioeconomic environment are either homogeneous enough or unsettled but easy to measure.

Two principles are used to guide the formation of a sample: 1) each sample must contain the same variety as in the overall population, and 2) the sampling must be based on a recent census, otherwise a census will have to be conducted as well. Thus, a double stratification is made of the farming population: according to natural and socioeconomic characteristics; that is to say, soil zones, climatic zones, extension area, etc., and, according to size and productions of farms. The farm sample must include

each class of farm in each environmental zone.

If no census exists which is detailed enough to draw up classes and select by drawing lots, it is possible to first make up a sample according to geographical zone and then make a census of the farms in the selected zone. Using this procedure, it is only necessary to make a survey of 10% of the population.

Farm Study

Each farm survey takes about four hours. A lot of information is collected. So, in order to check the truthfulness of the data collected, the interviews are alternated with information analysis. A manual is provided to help the investigator when conducting surveys.

A farm study is made up of four parts. In the first part, we try to tear out the strategical choices; that is to say, the choices that lead the farmer to adopt a particular farming system. This part includes a characterization of the farming system, such as size of farm, productions output, and management. It also includes research into the features that determine the choice of the farm system, such as the family, history of the particular farm, characteristics of the environment, the farm building, farm equipment, and the number of farm hands, all of which will influence the choices. All of these relationships are summed up in order to determine the process that leads eventually to the farm choices and plans for the years ahead. A working hypothesis is that farmers are rational in making strategical choices, given their objectives and their technical and economic knowledge.

In the second part, a number of subsystems (cropping systems, cattle breeding, etc.) are identified, described, and judged independently of the farm family. In the third part, the two previous parts are brought together and provide a confirmation or a modification of the formulation of the strategical choices, and a judgment on and a detection of farming problems and suggested solutions is made. In particular, it is possible to determine what technical advice will improve the situation. Figure 2 shows the result of these three parts. In the fourth part, we ask for information about changes in the family, objectives, productions, and management over the last twenty years. We can analyze past events in order to bring out a few main changes in strategical choices and their internal or external causes. Development stages can thus be identified as being linked together through various change mechanisms.

Farming Systems Classification

We put together the farms according to a double classification: one according to farm functioning types whereby each type consists of farms with similar strategical choices (or similar functioning diagrams as shown in Figure 2), and the second according to evolutionary paths where each progression consists of stages in development and mechanisms for change which are held as similar for several farm histories. We then focus on different stages in the process corresponding to present functioning types

and mechanisms, relating a present type to another one. Figure 3 shows an example of an evolutionary path.

The causes for the particular evolution of the farms up to the present are attempted to be explained by this process. In this way, one tries to comprehend the salient points in the evolution of the different types, as well as the historical changes from one type to another (Capillon and Manichon, 1970; Capillon and Sebillotte, 1980).

The approach may be summarized as follows: criteria or indicators[1] are extracted for the totality of farms surveyed. The criteria are an expression of the various existing systems, as well as of past evolutions. The indicators serve as a basis for a preliminary classification used as a working hypothesis. The classification is then tested and modified until a greater homogeneity in farm functioning and past farm evolutions is obtained within each group. Once this is achieved, it should be possible:

- to select a set of characteristics for present farm functioning resulting in the definition of a farm type;

- to group these various types along several evolutionary paths, characterized by evolutionary mechanisms and stages expressing a coherent process of evolution, and

- to place each individual farm within a type and each type on one of the evolutionary paths thus defined.

On the basis of this grouping, the results obtained are verified by checking whether a new sample of farms will fit into the classification.

Once a study has been completed, one should be able to place any given farm within a type without going through all the lengthy process of farm survey. With this in mind, we have drawn up a key consisting of simple criteria, such as acreage, main activities, etc., which will enable one to place any given farm in its correct type. Afterwards, one verifies the concordance of the strategical choice of the given farm with the chosen type.

The approach described above could be said to be less objective than that in which farm type descriptions are based on statistical data. This is due in part to the fact that the definition of trajectories cannot as yet be based on a proven theory. The methodology of this approach requires further investigation. In order to overcome existing imperfections in the theory, two *a posteriori* tests are indispensable: 1) a validity control of the classification established within the sample of farms surveyed (using discriminant analysis, for example), and 2) a validity control carried out on a wider sample of farms.

With these controls, the approach proposed here allows, in many cases, more efficient use of survey data. Indeed, in some instances differences which may occur for certain criteria within the samples are not statistically significant. By placing these criteria within a different

frame of references, one can avoid their meaning being obscured by the slightness of perceptible differences.

FARMING SYSTEMS CLASSIFICATION: PRELIMINARY TO A REGIONAL EXTENSION PROGRAM

This typology enables one to study the past evolution of farms and to propose certain actions for the future. One can illustrate this with an example taken from a study of the agricultural situation in *Boischaut Sud du Cher* (Capillon, Leterme, David, 1984a, b). This is a region in the center of France where the principal output is Charolais beef production. Figure 3 represents the types according to the average farm size and the average farm income. The arrows indicate the different mechanisms which in the past have enabled the passage from one type to another. To be brief, we will only discuss types II (Table 1).

The different types developed from II A are distinguished by the relative importance of cattle breeding and of cereal crops destined for the market. Type II B first invests in farm equipment for crops. Type II C both invests in cattle breeding sheds, because he has acquired new land which has no farm buildings, and in equipment to produce fodder. Later, II B, in consequence of his low income, tends to develop towards II C by diminishing the growth of crops destined for the market and intensifying cattle breeding, with the necessary new buildings. As a consequence of too many tasks, II C tends to move towards II D. One increases the acreage and the proportion of crops destined for the market. This leads to a very intensive period of work in the springtime. Type II E does not have this problem because he has at his disposal wage-earning farmhands. It seems at present to be the most efficient system. It is the result of farms, developed over at least twenty years, which have been able to profit from loans at low interest rates and from a market which favored the production of breeding bulls that enables them to acquire land and to drain it.

The only two types that manage to produce high incomes cannot be taken as models for the others. Type II E can no longer be adopted as the conditions today are no longer favorable. Type II C is not very stable. The farmers are overloaded with work and cannot diminish this, as there is not enough money to employ farmhands. So, given that we know emerging premises of a number of farm types and conditions of their success well enough, it is possible to argue about their exemplary value in an extension program.

This study has underlined the difficulties faced by farmers as regards increasing their income from the basis of extensive beef production. The increased acreage was often turned into extensive pasture as a result of a lack of farm buildings, which were necessary for an extension of the herd, and of a lack of farm equipment for growing crops. This development of crop growing was made even more difficult by the excessive moisture in the soil because of bad drainage, and by the leanness of the soil, which had previously been extensively used as grassland.

One can deduce from this the following useful technical references.

Concerning cereal crops:

- How to improve the fertility of the soil? At what price? If this is not possible, what is the best possible yield within a given cropping system?

- For II D, it is necessary to adapt techniques of wheat cultivation that are compatible with springtime, which is heavily taken up with the calving season. Otherwise, the yield will remain low in spite of the large quantities of fertilizers used.

Concerning cattle breeding:

- Develop a form of range management that most efficiently utilizes investments and grassland, such as combination stocking for Types II A and II B.

- Develop a farm management that is less expensive regarding farm labor, which gives greater importance to the use of permanent grasslands.

FARMING SYSTEMS CLASSIFICATION, A RATIONAL BASIS FOR BUILDING-UP TECHNICAL REFERENCES

The building-up of various technical references suitable for one region presupposes a number of trials or technical surveys which take into account both the environmental and farm constraints. The typology constitutes a basis for creating these. Thus, in *Marais Poitevin de Vendee*, a region of marshlands near the sea, the study of soil tillage for the production of corn was made, in conformity with the above methodology (Capillon and Tagaux, 1984; Capillon and Pellerin, 1984).

The principal features of the natural environment are: maritime climate with mild temperatures, lack of rain in summer and excessive rain in winter (Figure 4), and heavy clay soils. This leads to the proposition for the following techniques: plowing at the end of summer or the beginning of autumn in dry conditions, and ditching, weeding, and preparation of seedbeds before the rainy period, even for maize. In 1981-82, the study found three different categories of techniques used in farms which are specified by various dates of plowing and posterior tillage (Table 2). These categories of techniques are more or less frequent, depending on the type of farming system (Table 3). Types C and F appear to be the best performers. On the other hand, Types B and D perform less well.

One can relate these different techniques to the different possibilities concerning the organization of works. For example, one can put in opposition the two extreme types. In Type B with low acreage, the farm family has housed a small dairy herd in an old barn. The crops are destined for market, with wheat straw gathered for cattle breeding.

Considering the low level of farm equipment and the paucity of farmhands, one can envisage a long time taken up in straw gathering, resulting in a postponement of the plowing. Again, the low pulling power of tractors brings about difficulties of plowing in dry conditions. Type C increased their acreage and dairy cattle, with new housing and milking facilities. High levels of farm equipment and labor allow them to properly prepare the seedbeds before the rainy season. As a result of the above considerations, one must take into account inflexibility of the work organization in order to give the correct advice in soil tillage, and try to better use the plots which are plowed late. A number of trials were carried out experimentally in order to find solutions for Types B and D.

CONCLUSION

For quite some time, the diversity of farms within the same region was considered as an obstacle to the diffusion of technical progress. Today, the economic crisis tends to modify the value of things. Some points of technical progress which yesterday were seen to be favorable today look rather risky, not to say dangerous. On the other hand, one is sometimes astonished to realize that certain farms, up till now seen as nonproductive, seem to do better than other farms which have profoundly modernized their farms. One is thus forced to look carefully at all different categories of farms in order to understand the origin of their difficulties or the absence of these.

The method described above may appear long, but in our present state of understanding, the system of automatic classification is unsatisfactory and the methods for studying farms and for grouping these into types is not as yet codified. It thus appears necessary to gain a deeper understanding in order to know how to judge what are the changes in methods that are for the best and to better coordinate the different interventions within the region. We can only set up experiments, often very expensive, if we first question ourselves as to their real usefulness regarding the farmers in the region.

Lacking a deep understanding of the regional agriculture, one is not capable of defining the extension programs that are most necessary and pertinent. It is not enough to know that your experimental program works; you also have to know what type of farm and farming conditions makes it appropriate.

Development organizations, both private and public, technical and commercial, are more and more taking these considerations into account. Programs for the education of extension officers include an initiation to these methods. Moreover, the method explained in this paper has been used in other countries regarding the organization of their strategies of study and development in Mexico (Turrent, 1983) and in the French West Indies (Pellerin and Ney, 1985), to mention the most recent examples. Finally, these methods pose new questions for agronomists. They must design new techniques that correspond better to the needs and possibilities of farm types.

Footnote

[1] These criteria depend on the region considered (natural conditions, socioeconomic environment) as well as on the exiting farming systems.

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TYPE	II A	II B	II C	II D	II E
Farm acreage (ha)	50-90	80-130	70-100	70-80	100-160
FREQUENCY :					
. In farm population (%)	20	12	6	3	5
. *In regional area (%)*	*18*	*16*	*8*	*4*	*8*
% of permanent grassland to farm acreage	75-100	40-70	60-85	50-60	20-60
% of crop destined for market to farm acreage	0-15	20-35	-	25-35	15-50
Nb. of workers	1-2	1,5-2,5	1,5-2,5	1,5-2	3-2,5
Beef cattle : Number of cows	30	30	50-60	25-30	50
Other animals species	-	-	-	Sheep	Pigs

TAB. 1 - MAIN FEATURES OF FARMS - BOISCHAUT SUD DU CHER (CAPILLON, LETERME, DAVID, 1984 a and b)

(Survey conducted in 1983 ; sample included 70 farms from a total population which consists of 800 farms and 49 000 hectares)

TAB. 2.1. - CATEGORIES OF TECHNIQUES, THEIR REPERCUSSIONS ON SOIL STRUCTURE AND EMERGENCE OF CORN

CATEGORY OF TECHNIQUES	DATE OF ploughing	DATE OF seed bed preparation	QUALITY OF SOIL STRUCTURE Seed bed	QUALITY OF SOIL STRUCTURE Beneath	EMERGENCE PERCENTAGE
I	Early (1) In dry conditions	Autumn (early)	++	++	> 75%
II	"	Autumn (late) and spring	+	++	50-60%
III	Late In wet conditions	Many tillages in spring	-	-	36-55%

(1) *Before September 25, 1981*

Legend : ++ : Favourable conditions for emergence or root development
+ : Intermediate " " " " "
- : Unfavourable " " " " "

	July	Aug.	1-24 S.	25-30 S.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
R (mm)	15	33	30	62	156	11	189	59	54	67	1	27
R-ET	-96	-92	12		114	-17	172	38	28	15	-97	-76

TAB. 2.2. - RAINFALL AND EVAPOTRANSPIRATION FROM JULY 1981 TO MAY 1982

(Marais Poitevin de Vendée)

CATEGORIES OF TECHNIQUES	TYPE OF FARMS			
	B	C	D	F
I	45 *48*	86 *82*	42 *53*	74 *88*
II	15 *19*	14 *18*	29 *29*	14 *10*
III	40 *33*		29 *18*	12 *2*

TAB. 3 - FREQUENCIES OF CATEGORIES OF TECHNIQUES ACCORDING TO TYPES OF FARMS

Legend : Frequency of a given category of techniques within a given type of farm

45 : % of number of plots
48 : % of acreage

TYPES	B	C	D	F
% of farm population	13	5	8	5
Farm acreage (ha)	30-60	50-100	60-100	80-150
Tilled land area (ha)	20-55	45-100	50-100	60-150
Proportion of cereals crops to arable land (%)	50-90	50-70	60-80	60-80
Proportion of corn used as a forage crop to arable land (%)	0-10	15-25	0-20	0
Proportion of corn grown to produce grain to arable land (%)	10-30	0-25	10-30	15-40
Cattle	10-15 DC (1)	30 DC (1)	Semi intensive beef production	-
Higher power of tractors (HP)	50-80	90-120	60-100	90-120
4 Wheel-drive-tractor	-	++	+	++
Rotary cross harrow	+	++	++	++
Individual ditcher	-	++	+	++
Straw pick-up baller	-	+	-	+
Nb. of workers	1	2	1,5	2

Legend : DC : Dairy cows
++ : Always present in farm equipment
+ : Often present in farm equipment
- : Never present in farm equipment

TABLEAU 4 - MAIN FEATURES OF FARMS (Marais Poitevin de Vendée)
(CAPILLON, PELLERIN, 1984)

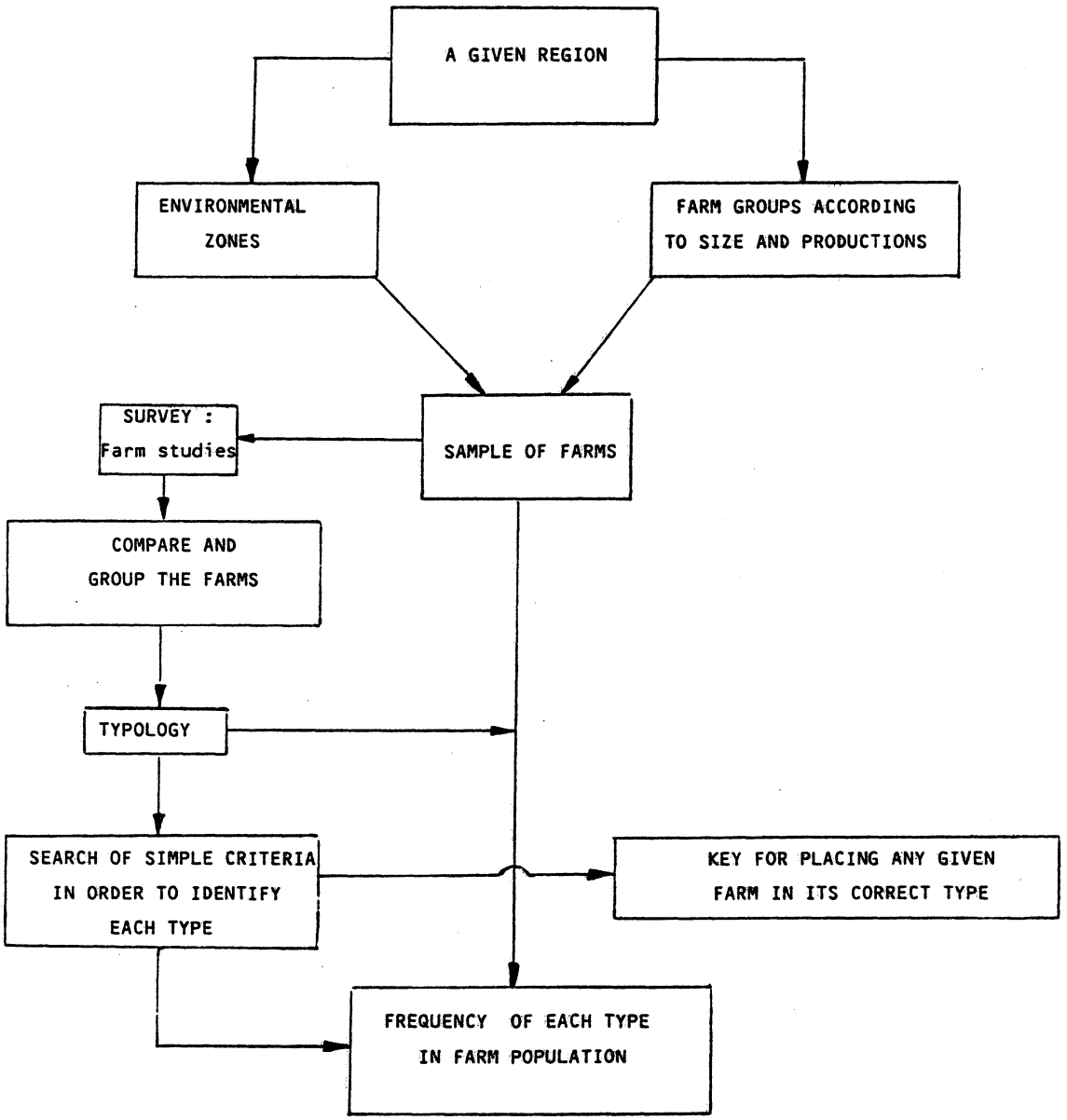


FIG. 1 - DIFFERENT PHASES IN THE METHODOLOGICAL APPROACH

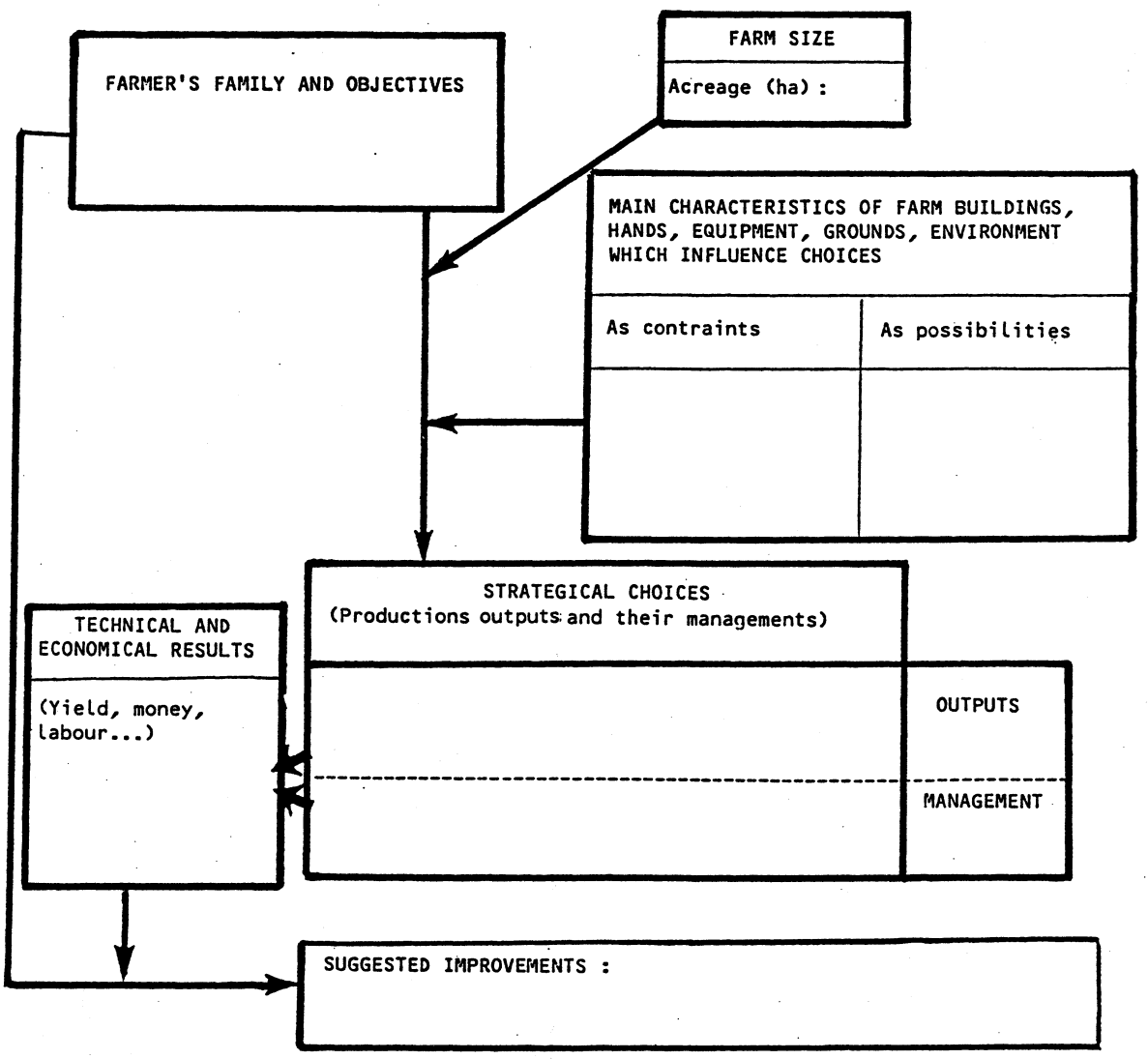
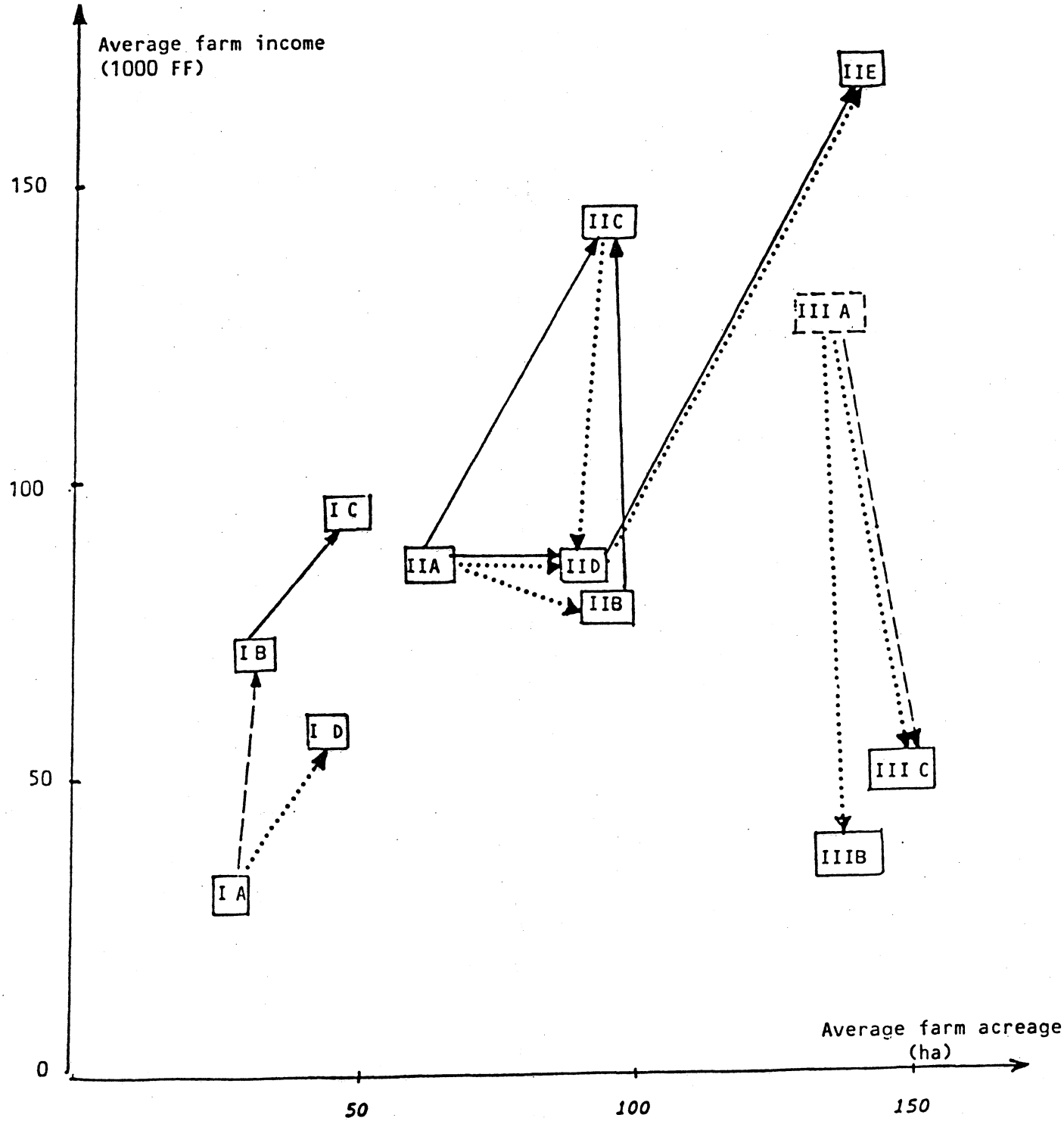


FIG. 2 - A MODEL OF FARM STUDY



Dynamics of farms ; Mechanism for change :

——► Increase in cattle stock

····· ► Increase in crops destined for the market

····· ► Increase both in cattle stock and crops

— – → Addition of new produces (poultry, tobacco, market gardenning)

FIG – 3 - FARM TYPES ACCORDING TO THE AVERAGE FARM SIZE AND THE AVERAGE FARM INCOME

(Boischaut Sud du Cher ; CAPILLON, LETERME, DAVID, 1984 a and b)

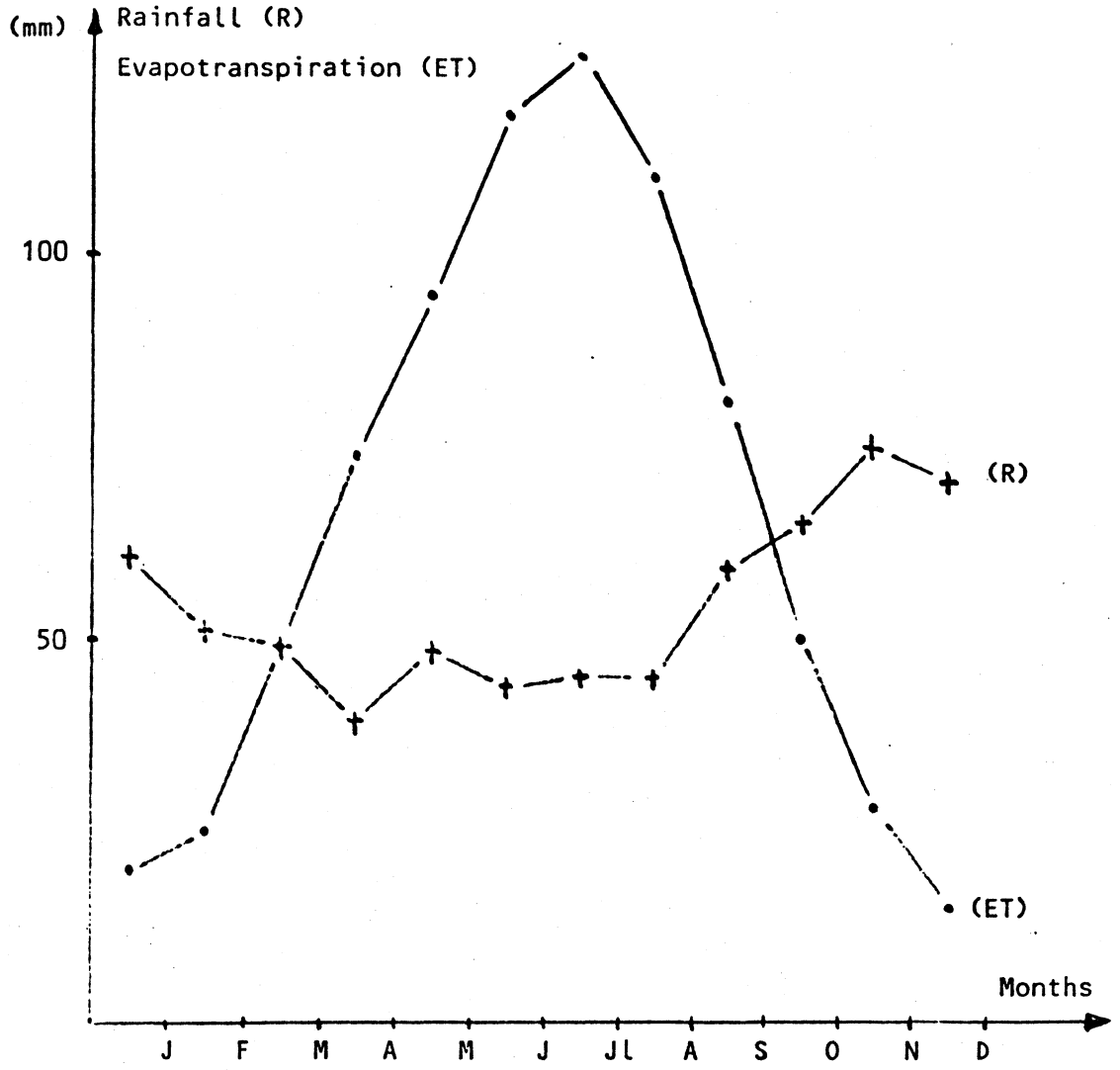


FIG. 4 - AVERAGE MONTHLY RAINFALL AND EVAPOTRANSPIRATION
(Ile d'ELLE, Marais Poitevin de Vendée, 1963-1980)

RECOMMENDATION DOMAINS RECONSIDERED

Tully R. Cornick and Amalia M. Alberti

INTRODUCTION

Over the past decade, Farming Systems Research Projects have proliferated in many countries and regions of the world as a research approach to the adaptation of agricultural technologies appropriate to the circumstances of small farmers. Premised on the promise of efficient and rapid research results widely applicable to large areas and populations, and emphasizing second best and optimal technologies (Norman and Baker, 1984), Farming Systems Research (FSR/E) development programs have been recipients of significant human and financial resource investments from international donor agencies, international and national research centers, and government agencies. Following an initially euphoric and somewhat unquestioning acceptance of FSR/E as a remedy to the technological problems faced by small farmers, practitioners and evaluators alike have begun to raise questions about the promise and directions of FSR/E (Weise, 1985; Price, 1982). A growing debate has emerged concerning some of the basic tenets of FSR/E and its ability to produce timely and meaningful results. Central to the FSR/E approach and this growing controversy over its ability to produce timely and meaningful results is the concept of Recommendation Domains.

This paper develops the argument that considerable conceptual haziness surrounds the Recommendation Domain (RD) concept and the manner in which it is operationalized, to the point that it may occasionally obscure recognition of the physical and social reality in which FSR/E is operating. After attempting to reduce the scope of the concept to what we believe are more manageable and meaningful terms for FSR/E project implementation, we identify and discuss two major aspects of farming systems that require consideration in the development of RDs.

Recommendation Domains Review

The concept of Recommendation Domain was first articulated by the economics program at CIMMYT (Perrin, et al., 1979; Byerlee and Collinson, et al., 1980) in the late seventies, when FSR/E was gaining popularity as an innovative research approach for adapting technology appropriate to the conditions of small farmers. At the time, the need to reduce the natural heterogeneity of rural areas and small farmers into homogeneous farmer groups for both research and extension purposes was correctly recognized (Weise, 1985). If FSR/E was to be cost effective, research activities had to address problems of, and provide solutions for, relatively large numbers of people. It became necessary, therefore, to " . . . classify farmers with similar circumstances into recommendation domains--groups of farmers for whom we can make more or less the same recommendation" (Byerlee and Collinson, et al., 1980). The sheer impossibility of developing research activities and discrete recommendations for masses of individual farmers required that target areas and target populations with sufficient common characteristics and potential (Shaner, et al., 1982) be identified as the

focal point of research and extension efforts. Since then, the RD concept and its operationalization have become a central feature of FSR/E.

In the period following the original conceptualization of RDs and the development of initial guidelines for establishing them, FSR/E projects spread throughout temperate and tropical areas of the Third World. The collective body of knowledge pertaining to FSR/E increased enormously as discrete FSR/E projects confronted the institutional, environmental, and socioeconomic realities of their research areas. FSR/E developed new modalities of expression, improved forms of farmer participation, and new approaches to problem identification and resolution. The concern expressed here is that developments in the RD concept and implementation have not kept abreast with developments in FSR/E.

As originally conceived, definitions of RDs, derived from secondary data sources, often preceded (Collinson, 1982) or were virtually synonymous with site selection and the indentification of target groups (Bernsten and Malian, 1980; Zandstra, et al., 1981).[1] Verification of homogeneity of the initial RDs identified were made early in the FSR/E process through formal and informal diagnostic surveys (Gilbert, et al., 1980)[2] and any required, subsequent refinements in the RD occurred very early in the research process.[3]

Recommendation Domain definitions were parsimonious in nature, distinguishing comparatively large groups in relation to a few discrete factors. Physical properties of an area, such as soil type, topography, and climate, generally formed the basis for the initial delineation of RDs. Social, economic, and cultural factors (e.g., farm size, market access, and ethnic identity) were considered secondary factors brought into the RD equation when necessary (Norman, 1980; Gilbert, et al., 1980), but, as the term implies, the physical and geographical characteristics of RDs were generally determinate.[4]

These quintessential characteristics of RDs, the parsimonious use of determinate or characterizing factors and the early development of RDs within the FSR/E implementation process, were recently reaffirmed in the CIMMYT publication, "Recommendation Domains: A Framework for On-Farm Research." Writing with reference to RD definition and scope, the authors note: "It may be that the area is homogeneous enough to constitute a single recommendation domain. If not, there are usually one or at most a few key circumstances that can be used to define domains" (Harrington and Tripp, 1985, page 13). It is perhaps the relatively narrow scope of RD definition that allows for what we believe, given the current state of FSR/E, is a very rapid finalization of RD development within the overall FSR/E process. The authors tell us: "At times, (our emphasis) it is only after a year or more of experiments that researchers are able to make the final adjustments in their domains" (Ibid. page 15). The paradox is that we FSR/E researchers often seem to be defining RDs before we have come to grips with the farmers' problems, much less made significant advances in developing solutions to them.

If one assumes that the final criteria for RDs is the extent to which

they accurately describe the population that eventually adopts a recommendation (Fresco, 1985), the apparent paradox is not new to FSR/E. It is implicit in all of the early discussions of the RD concept stressing definition before problem identification or understanding of the farming system.

FSR/E today is quite different from FSR/E at the time when the RD concept was first developed. Collinson (1982), one of the few writers to discuss his assumptions with respect to the concise time frame for development of RDs, identified three factors underlying the process described: the involvement of experienced professionals, a process of adaptive technology, and an ongoing research program. While such conditions may still be met by the international agricultural research centers (IARCs), many current FSR/E programs involve young and inexperienced staff within line agencies of Third World countries who have little previous experience in on-farm work or research and little in-depth knowledge of agricultural production in the target area. It is not uncommon that the logistical and implementation difficulties encountered in mounting an FSR/E program, such as getting people trained and operating in the field, identifying research problems, and initiating on-farm research, may consume more than the time usually allocated in the literature for RD development.

Other changes in FSR/E can also be identified. The small farmers' world has become vastly more complex to FSR/E researchers as FSR/E projects have adopted a "whole farm" approach in contrast to the mandated commodity orientation of the IARCs. The more holistic approach brings with it all of the attendant difficulties of untangling and understanding the interdependent relationships of multiple major and minor crops, livestock, and off-farm enterprises within a farm system.

As our awareness of the complexity of the small farm environment and system expands and our understanding of the obstacles facing the rapid implementation of FSR/E projects grows, our insistence on defining RDs in simple terms early in the research process, with only nominal recognition of the need for substantial review and revision later, can be viewed as a questionable methodological practice. The scant and sometimes doubtful quality of secondary data in many Third World settings can pose serious threats to the accuracy of RDs, even tentatively developed, if a subsequent, substantive reassessment is not a component of RD elaboration.

Reliance on informal or formal diagnostic surveys in the early phase of FSR/E may not be sufficient for verification and finalization of RD groups. Diagnostic surveys have been demonstrably successful (Beebe, 1985) in satisfying the purpose for which they were developed: as cost effective short-term information collection methods to provide the minimal necessary information to initiate on-farm research in a somewhat informed fashion. They are not infallible, however, nor are they designed to provide information on many factors critical to good FSR/E. Price's recounting of an IRRI experience demonstrates this point well: " . . . environmental diagnostics are best used as heuristic devices. . . . It is only through field research at a locale that we discover what factors are important in a locale. . . . It was a good two years in Iloilo before we fully recognized

the influence of landscape position on cropping patterns. We originally considered the land to be homogeneous" (1984, p. 4). A similar case can be made for many important sociocultural aspects that may not come to the fore in the short time allotted most diagnostic surveys (Gladwin, 1983). This is particularly true when used as "one-shot" data collection methods.

We are concerned that even after a year or more of field work, projects may not be in a position to realistically assess many of the assumptions related to the homogeneity of the RD. For projects with new and inexperienced staff, the first year's trials are sometimes overwhelming, leaving little time for addressing questions not directly associated with the mechanics of implementing on-farm trials.

The early identification of recommendation domains, even when well done, presumes that the environment and RD population are relatively static, a condition that may not hold over time. Oftentimes, both environmental conditions and the target populations are characterized by a dynamism that has a sporadic and intermittent quality. It resists identification and measurement over short periods of time and cursory examination. FSR/E researchers recognize that farmer problems and priorities will change over time, particularly as solutions are found to the originally defined set of problems. We refer, however, to changes in problem identification and priorities over time with no change in farmers' capacity to handle the first problem identified, because the context in which the original problems and priorities were established has changed, or because the circumstance on which the original RD was derived has been substantially changed for many farmers.

We take the position that early establishment of RDs defined along simple one or two factor lines is unwarranted in areas where natural or socioeconomic conditions or both are highly variable. It may even be prejudicial to research efforts to force assumptions of homogeneity on farmer groups and conditions when such assumptions are not necessary to the conduct of initial on-farm field experimentation. The danger is that premature assumptions of homogeneity may foreclose identifying research opportunities and strategies deriving from unidentified but significant differences within a cursorily defined RD group. Field experiments, like development projects, can assume a life of their own if procedures to re-evaluate the research and assumptions on which they are premised are not built into the initial research design.

The identification of critical factors determining acceptance of a recommendation by a target group of farmers can be arrived at through the on-farm research process, an activity generally requiring several years to complete. The selection of target area and population can be regarded as conceptually distinct from that of initial and final determination of the RD group,[5] the former placing emphasis on identifying both a broad range of potentially relevant variables and the nature of the production system. Rather than assuming homogeneity on the factors selected to identify target areas and groups, field experiments can be designed to span the potential variability within each factor (treating them as if they were gradients), thus testing both the robustness of the technology under consideration and

the degree of homogeneity or variability of the factors informing the research.[6] Two features distinguish this from the original RD approach: 1) explicit examination of the variability of factors for characterizing the target area and group, and 2) a relaxation of the time frame in which RDs are finalized. These modifications would permit the early conduct of on-farm field experimentation concurrent with an examination of factors potentially relevant to the specification of RDs.

It is within this context of a refined RD development process that does not posit the prompt completion of RD identification, thus implicitly allowing for development of more complex RDs, that we suggest, based upon FSR/E field experiences in the highland Andes of Ecuador and the central Philippines, consideration of two major factors to heighten the relevancy of recommendation domains for many marginal agricultural settings. These include the recognition that: 1) many small farm systems are purposively distributed across multiple agroecological areas or zones so that production practices and decisions are a function both of the conditions of the specific agroecological zone to which they pertain and of the other zones in the farm system, and 2) intrahousehold dynamics, although time consuming and difficult to explore, is often a critical discriminating factor to accurately describe the population for which a particular problem solution is appropriate. Both concerns can perhaps be summarized in a single guideline for RD development: that RDs explicitly consider other subsystem interactions outside the immediate research problem.

Agroecological Zones--Definitive Recommendation Domain Boundaries?

Agroecological zones are usually treated in FSR/E literature as the first and highest levels of discrimination within RD development. Existing procedures for RD development are predicated upon the identification of homogeneous agronomic and environmental conditions within which further RD refinements are elaborated as needed (Gilbert, et al., 1980). Descriptions of RDs tend to assume implicitly, if not state explicitly, that: "Generally, a recommendation domain will consist of farmers within an agroclimatic zone whose farms are similar and who use similar practices" (Perrin, et al., 1979).

While a number of FSR/E projects describe areas where it is commonplace for farm units and farming systems to be wholly contained within all or part of an agroecological area (Barlow, et al., 1981; Collinson, 1982; Norman, et al., 1983), these areas contrast markedly with, for example, the central Andean highlands of Ecuador or the Eastern Visayas region of the Philippines. In these latter regions, variability within the physical environment is sufficiently pronounced that small farm agricultural systems have evolved explicit strategies of exploiting multiple agroecological zones as risk distributive mechanisms. Under conditions of environmental variability, traditional views of RDs that limit the research focus to the agroecological zone in which the research is conducted may be too narrowly defined to be viable. An essential element of RD development in such contexts is the researchers' knowledge of farmer strategies and adaptive responses to that patterned variability in environmental conditions of production systems that cross agroecological zones.

Although farmers are powerless to influence changes in climatic conditions, they recognize the patterned differential effects these climatic fluctuations have on the productive characteristics and potential of diverse agroecological zones. In the two examples from Ecuador and the Philippines that we describe below, we argue that farmers have developed strategies to optimally exploit the variable productive potential of multiple agroecological zones under fluctuating climatic conditions. In deciding whether and how to produce a given crop or complex of crops in a particular agroecological zone, farmers must not only consider the expected conditions within the agroecological area to be planted, but also what will occur in other areas and how that will affect the total farm system. Oftentimes, this is an iterative process concurrent with the actual production phase of various crops in diverse agroecological zones in which farmers react to rather than anticipate climatic changes. In either case, whether farmers are deciding in anticipation of expected climatic outcomes or reacting to climatic conditions at a given moment, their responses are based on past personal experiential knowledge and the shared collective wisdom of earlier periods with similar conditions when the effects of these climatic fluctuations on different agroecological areas were observed.

Under highly variable climatic and agroecological conditions, farmers may not maintain a constant set of crops, crop associations, cropping patterns, or cultural practices from year to year, but instead choose to rely on flexibly constructed cropping patterns that permit a great deal of latitude for last minute changes. A consequence of shifting farmer strategies in response to the interaction of climatic changes and agroecological conditions is the variation in the range of crops produced and cultural practices used from year to year. The difficulty for the FSR/E researcher is that the failure to recognize the temporal dimension of the cropping pattern or system initially identified and made the subject of research carries the risk of narrowly focusing on what may comprise only a subset of crops and practices belonging to the system and given RD within a period of several years.

The complete cropping pattern, as well as the full range of factors devolving from the larger production system within which a given piece of developed or adapted technology should fit, may not manifest itself in its entirety until fluctuations in climatic conditions have ranged across all probable extremes. Apart from the most extreme conditions of drought or excessive rainfall, there is a range of "normal" climatic variations and extremes for which farmers have a repertoire of adaptive production strategies. Both research design and RD definition may require modification as these farmer strategies that so markedly affect the nature of the cropping system are first utilized by farmers and then identified by researchers.

As our first example, we consider the case of Quimiag, Ecuador, a small community on the eastern slopes of the inter-Andean basin in the province of Chimborazo. Situated at 2700 m above sea level, Quimiag farmers cultivate and graze livestock on land that ranges from approximately 2300 m above sea level to over 4000 m. At a steady pace, the entire altitude range can be

crossed on foot within three hours in an uphill walk.

Within the basin, and particularly on the steep slopes of the mountains and volcanoes rising above the basin floor, altitude and rainfall are strongly and positively associated. In contrast, temperature is negatively associated with both. At the lower extremes of the vertical gradient, higher average daily temperatures and lower annual rainfall averages are found; as one moves up the altitude gradient, rainfall increases and daily temperatures drop precipitously until finally one reaches the frozen snow covered peaks of the larger volcanoes. A vertical pattern of agroecological zones arranged along the altitude gradient is the product of this association of altitude, temperature, and rainfall.

Allowing for some exceptional ecological niches that do not conform to the general rule, crop production within the Quimiag area is limited to the 2400 to 3600 m range. Although tuber and cereal crops are grown throughout much of the altitude range, the optimal production zones for each vary. Broadly speaking, environmental and agronomic conditions are most suitable for potatoes, faba bean, and cabbage production above 2800 m, while corn and beans are best suited to the area under 2800 m. Over three years of research, however, Quimiag farmers were to demonstrate that such generalizations are deceptively simple.

In 1978, following a rapid rural appraisal and a formal survey, a team of FSR/E researchers in the Quimiag-Penipe project[7] identified a number of *conjunto productivos*, or recommendation domains, including two covering altitude ranges from approximately 2400 to 2700 m and 2700 to 2900 m. Within the lower *conjunto productivo*, a predominant corn production system, monocropped maize followed by a crop of potatoes, was identified. In the second, higher altitude RD, a system of maize x bean intercrop predominated. Other minor cropping patterns of maize x faba bean, maize x carrot, and maize x potato were identified but not selected for research because of their lesser importance in the area. Based upon the low corn yields combined with its major role as a food staple, the project staff decided to focus on increasing corn productivity by using improved maize varieties with minimal applications of chemical fertilizers. Use of improved bean varieties to increase bean production for the maize x bean intercrop was targeted as well.

During this time, the project area entered a historically recurrent period of drought. Farmers had already begun responding to the changing climatic conditions by modifying the crop components and moving them into altitude ranges higher than those identified for those cropping patterns. Since the researchers were unaware of these changes, however, the trials were established based on the predominant crop system for each of the two RDs earlier identified through the rapid rural appraisal.

The following year, as the drought continued and warmer overall temperatures prevailed, farmers reacted by again moving the corn x bean cropping pattern upward an additional 100 m and eliminating the beans. In its place, a single system of monocrop maize dominated the entire area earlier identified to contain two distinct recommendation domains based on

different systems of corn production.

By the beginning of the third year, farmers' responses to the continued drought had taken an improved early maturing INIAP variety of maize up to 3200 (400 m beyond the altitude ceiling established by INIAP for that variety), and a maize x faba bean intercrop had become the dominant cropping pattern for maize within an area that had previously been best suited for more cold resistant tuber crops and pastures.

By this time, with the help of farmers, researchers were able to reconstruct and define the broader strategies underlying the cultivation of maize, maize x bean, and maize x faba bean cropping systems, as well as their manipulation across agroecological zones in response to long-term fluctuations in temperature and rainfall. That system is schematically portrayed in Figure 1.

The corn production systems of Quimiag reflect the farmers' ability to respond to dynamic changes in moisture and temperature and successfully intercrop a legume with corn to produce a harvest from both. When weather conditions permit, the farmers' preferred practice is to intercrop maize with either beans or fabas. Borderline fields between the zone optimal for bean production and the higher zone more appropriate for faba bean production are frequently planted to maize, with an intercrop of beans and faba beans planted every other row. In a cold, rainy year, the faba beans thrive and the beans die out; the reverse occurs in warmer and drier years. Monocropped corn is planted only where beans are not expected to grow because of insufficient moisture and is the least desired cropping pattern. The intercropped beans and faba beans are moved up or down the altitude gradient in accordance with farmers' perceptions of what the best intercropping for the climatic conditions of that year appear to be.[8]

The ceiling for cultivation of maize is similarly determined by farmer expectations of how warm a year will be. The last year's performance of maize in the highest fields and the weather conditions at the time of planting serve as the farmer's indicators.

From the point of view of RD development, the critical difference between researchers and farmers, at least initially, was that the former treated the interaction of climate and agroecological zone as a constant, both in defining RDs and in the research design, while farmers anticipated and perceived the patterned variations and reacted accordingly. Researchers' efforts and farmers' strategies were at odds with each other until we researchers gained enough experience and understanding of the environment to grasp the manner in which farmers adapted their cultural practices to fit environmental conditions at particular points in time. Both the assumed constancy of cropping patterns within a RD and the invariant agroecological character of recommendation domains reflected a mind set on the researchers' part that was not easily altered.

Despite very different environmental and climatic conditions across the Pacific, parallel situations can be observed in the Farming Systems Development Project--Eastern Visayas (FSDP-EV), the Philippines. The

project is mandated to work with small-scale upland farmers who grow subsistence crops of cereals and tubers. In contrast to the Ecuadorian case where farmers shift cropping patterns across agroecological zones in response to climatic variation, Eastern Visayas farmers shift priorities in crop production from one zone to another and modify cultural practices within an agroecological area in accord with the shifting set of priorities in the larger farm system. Common to both cases is the fluid nature over time of the specific cropping system under investigation. Failure to recognize and understand the importance and complexity of this feature of the upland system in the Eastern Visayas initially resulted in less efficient research activities, often in conflict with the highly flexible local system of production encompassing changing patterns of priorities and different production strategies over time.

The FSDP-EV covers six different sites, each selected to represent a distinct set of upland production conditions. Despite these differences, all six sites are characterized by upland farming systems comprised of multiple agroecological areas. We discuss only one of them here.

The site of Jaro, Leyte is an exemplary case of farmers mixing several agroecological zones within a single farming system. Within the site of Jaro are found areas of lowland irrigated rice, lowland rainfed rice, and upland areas covered with dense stands of coconut and banana intermixed, with more open areas where cereal and tuber crops are produced. In the higher elevations, plots are still cleared of forest for shifting cultivation. The uplands are sufficiently marginal that farmers do not confine their production system to a single agroecological domain, but spread it across multiple, upland agroecological zones and down into the lowlands wherever possible. Exploitation of both lowland and upland areas tends to insulate farmers from the vagaries of nature that include frequent typhoons that flood the lowlands and droughts that parch the uplands.

In accordance with the project's mandate to work with small-scale upland farmers for whom cereal and tuber crops represent a significant part of the subsistence diet, research in Jaro was directed towards improving the areas sparsely covered by coconut, under which staple crops are grown. Following a process of baseline surveys, rapid rural appraisal efforts, farmer meetings, and assessing what was believed to be available as improved technology, a decision was made to improve the local cropping patterns comprised of corn, upland rice, and camote grown under sparsely populated stands of coconut. The project's conviction that technology requiring only minor modification was available and that the most efficient form of research intervention was the well developed IRRI-Los Banos cropping pattern approach reflected the influence of the lowland based research model on project thinking (Cornick and Repulda, 1985).

Ambitious plans to improve the cropping systems under coconut by increasing the yield per crop through the introduction of improved varieties, fertilizers, and insecticides, and to intensify production by introducing second or third crops into the cropping systems rapidly conflicted with what farmers were doing. These conflicts centered on issues of labor availability, flexibility, and fallowing practices.

Land preparation and planting of test cropping patterns at times could not be carried out by farmers because they and their *carabao* were involved in preparation of lowland rice fields; or because, although the farmer was available, all labor in the area was tied up in lowland rice production; or, if the price of copra was high, in harvesting and processing coconuts. Because farmers have access to different areas of lowland irrigated and rainfed rice lands with significant variation in the onset of planting and other cultural practices, no clearcut pattern of labor conflict was identified.

Delays in scheduled plantings of local crops, brought about by drought, could not be accommodated within the proposed annual three-crop cropping system because of the disruption in timing of the subsequent crops in the cycle. Farmers, on the other hand, changed crops at will.

Conversely, heavy rainfall during what was regarded as the dry season found farmers reluctant to plant crops suited to the "usually" dry conditions. The less flexible schedule of the proposed intensified cropping pattern, based on 15- to 20-year rainfall averages, could not accommodate adjustments required by rainfall variations in the research period without disrupting the entire pattern.

As soil fertility in a field declined, farmers wanted to shift from areas under cultivation to new fields, leaving the older areas to fallow. The field trials, designed as annual cropping patterns, however, were supposed to stay on the same piece of land for the duration of the trial.

Over time, and through the sometimes trying process of cropping pattern trial implementation, we gradually learned the dominant characteristics of the upland farming systems in Jaro. First, many upland farmers have access to lowland irrigated and rainfed rice fields and attach tremendous importance to those fields vis-a-vis upland plots. For farmers too poor to have access to lowland plots of their own, lowland rice represents a major source of off-farm income in the form of palay. Thus, upland fields compete poorly against lowland rice fields for the producer's attention and for the allocation of both farm labor and draft animals.

Second, highly variable climatic conditions, particularly rainfall and the periodic occurrence of drought, differentially affect lowland and upland crop production systems. With the greater importance given the lowland rice component, however, the upland crop scheme is continually readjusted to accommodate the higher priority activity of planting lowland fields with the onset of rains. Similar priority is given to lowland weeding and harvesting. Conflict between lowland rice and upland subsistence crops for labor and other resources is resolved by "trading-off-on" or neglecting the upland crop. The extreme flexibility that permits the farmer to attend first to the lowland areas is gained by giving secondary importance to the upland cropping component. Hence, fixed crop calendars for upland crops are avoided.

Third, the importance of coconut (copra) production, relative to upland

crops, varies over time in response to fluctuating market prices of copra. As the price of copra increases, copra production (i.e., coconut harvesting, hauling, splitting, and processing) supplants the care of upland crops as a major farm activity, reducing it to tertiary rank in the farmers' set of priorities.

Fourth, and lastly, the rotation of crops within and among fields occurs in response to declining soil fertility.

In short, the presence and importance of the upland cereal and root crops within the Jaro upland agricultural systems are functions of the constraining factors of lowland rice production under variable climatic conditions, on the one hand, and the changing price of copra on the other. The project's choice of a cropping systems approach presupposed a relatively stable upland cropping system, as well as a fairly constant set of priorities on the part of the farmer. Neither condition is met in the upland farming systems of Jaro because the management of upland cereal and root crop production in that system is subordinate to the production needs of lowland rice, and occasionally of copra. Nevertheless, the highly variable agroecological structure of the Jaro farming system and the correspondingly dynamic and fluid nature of the upland crop component were not fully recognized and appreciated until two years into the research.

In the two examples from Ecuador and the Philippines, the early establishment of relatively simple RDs based on an inadequate understanding of the interrelationships between diverse agroecological areas within the farming systems inadvertently forestalled research efforts to improve on the local technology. Instead, it was through the research efforts that a more adequate understanding of the system and the nature of the RD evolved. The belief, however, that a RD had been defined contributed to researchers' overlooking the variability that affected the conduct of research and had profound implications for the general appropriateness of the technology being tested. A more cautious approach to the establishment of RDs and a willingness to continue to search for variability affecting research problems could have improved on and perhaps shortened the learning experience.

The difficulties inherent in trying to rapidly reduce complex agroecological environments into a few manageable factors may also be encountered when researchers apply the same approach to complex social systems. In the next section, the consequences of overlooking the importance of intrahousehold dynamics in the development of RDs for improved sweet potato varieties are used to argue for a more cautious and considered approach to RD treatment of the social environment of small farmers.

Intrahousehold Dynamics

The dynamic nature of farm household composition and relationships is often unrecognized in conventional FSR/E analysis of RDs when farm households are considered the basic unit of production, and hence, of analysis. Casual assumptions of unity of purpose, common and collective interest, and gender based division of household and productive labor among farm family members are generally unexamined in the early phases of FSR/E, if at all, given the

urgency of getting both project and field trials underway. The frequent scarcity of available secondary materials on the subject and the difficulty and time consuming nature of research on intrahousehold relationships affecting the farm system further contributes to the lack of attention paid this area.

Notwithstanding the perhaps extenuating circumstances that result in this frequent and common oversight in RD development, the interplay of work roles, relationships, and interests within rural agricultural households materially influences the degree to which improved technologies are deemed "appropriate" for a farming system. Even where such issues fail to obstruct the adoption of particular items of technology, considerations of equity and increased well-being of individual household members, in contrast to the general household, add to the relevancy of a concern for including intrahousehold dynamics in RD development. Our discussion here, however, deals with the effect of intrahousehold dynamics on the adoption of improved technology, for here is where its importance is often first forced upon our attention. Such was the case with the FSDP-EV's work with improved sweet potato varieties.

In the Philippines, among advances made in upland staple food crops, one of the more significant has been the development of improved "camote" or sweet potato varieties. Sweet potatoes assume a secondary position behind the preferred staples of rice and corn in the diet of most upland Eastern Visayas farmers. When, in the natural course of events corn and rice stocks are exhausted or natural disasters such as drought or typhoon strike and maize and rice harvests are destroyed, it is the sweet potato that emerges as the basic subsistence staple by which survival of the household is maintained. Although "camotes" are readily marketed, most upland small-scale farm households regard the sweet potato as their primary subsistence staple, to be sold only in small amounts when in surplus or when a source of cash income is needed. As is common in both Africa and Latin America with basic staples that also function as survival crops (Boserup, 1970; Chaney and Lewis, 1980; Lewis, 1981), major responsibility for the care and propagation of sweet potatoes in many regions of the Eastern Visayas is assumed by women, particularly during periods of household stress when male members migrate in search of work elsewhere.

When the FSDP-EV initiated its research program in 1983, it incorporated into its on-farm research verification trials of several of the more promising improved sweet potato varieties available. Two and a half years later, the project still works with improved sweet potato varieties, but our appreciation of local varieties and how their qualities fit within a subsistence-oriented small-scale farm system in which women share responsibility for production is immeasurably enhanced. The characteristics of the local and improved sweet potato varieties reflect very different perceptions of the role of sweet potatoes within the Eastern Visaysas small farm system.

The improved varieties, responsive to fertilizer and yielding increased tuber production of marketable quality (i.e., large, uniform size and shape), reflect a clear commercial orientation on the part of the plant

breeders responsible for their development. The new varieties are perceived by farmers as being bushy rather than ground hugging in form and smaller in size than the local varieties, allowing greater plant densities per area. One of the more touted qualities of these varieities is the even onset and uniform maturation of tubers. When the FSDP-EV introduced these varieties with their increased yield potential and associated characteristics into the trials, the conflict with traditional patterns of sweet potato production was not yet perceived.

The full range of incompatibility of these varieties with the subsistence oriented, small farm system was disclosed gradually as knowledge of local sweet potato production practices increased. With the exception of planting, where both men and women are active participants, the cultural care and harvesting of sweet potatoes are tasks usually performed by women, occasionally accompanied by children. Once a crop is established, little cultural care is required because the aggressively vining local varieties rapidly form a thick ground cover, crowding out most weeds. Once the tubers begin to mature, harvesting of sweet potatoes occurs gradually over a period of months, during which time mostly women collect enough large tubers every few days to satisfy home consumption purposes. Local varieties mature unevenly and continue to produce runners that also take root and form tubers throughout the vegetative and reproductive phases of the sweet potato. Although alternative methods of tuber storage, both as tubers and as dried chips, exist, they require a period of concentrated activity that must compete with the full daily workload of most women. Additional labor inputs must be made if the product is to be stored over several months and still maintain good quality. The preferred practice, in contrast, places minimal demands on the time of household members and allows extended storage of the crop.

The continuous formation of sweet potato runners further reinforces the extensive character of labor distribution within the system by eliminating the need to maintain small plots of sweet potato grown exclusively for cuttings for the next planting. The lengthy 7- to 8-month crop of local sweet potato allows farmers to maintain available supplies of slips throughout most of the year, thereby minimizing the production of propagation materials.

In summary, the traditional "camote" production system, with few cultural requirements and an extended harvest period, makes minimal labor demands on household labor and no demands for outside labor. Sweet potato production of local varieties is effectively managed by women without competing heavily with other activities or requiring the assistance of other household members because of the reduced labor requirements at any one time.

The improved sweet potato varieties have been largely rejected by farmer cooperators because they fail to meet the standards of local varieties. They require additional weeding because they do not cover the ground readily; they require that the harvesting be completed over a short period of time and demand the assistance of household members not usually employed in this activity, and possibly hired labor as well, as the tubers do not store well in the ground. Once harvested, the tubers must be sold or

processed and a new crop immediately re-established if the variety is to be maintained, hence making further demands on household labor at the expense of other activities or crops of higher preference.

The task now lies with the plant breeders to include in their breeding objectives the needs of the described subsistence farmers in light of the identified small farm patterns of labor allocation associated with sweet potato production, as well as the nature of the product's end use. Had more attention been paid early on to small farm use of sweet potatoes and the importance of specialized household labor patterns in their production, the many years spent in breeding and verification might have produced results more relevant to both market oriented and consumption oriented small scale farmers.

CONCLUSION

Early closure of simply defined RDs may have been justifiable in the past when international research centers with experienced professionals and ongoing commodity oriented research programs in Third World countries dominated FSR/E activities. Over time, however, FSR/E has undergone dramatic changes. FSR/E programs are having to grapple with the entire small farm systems in areas rarely studied before, with little or no available "shelf technology" for easy modification, and with staff gaining experience with FSR/E and on-farm research by conducting it. The critical time frame within which FSR/E can produce relevant and appropriate results is unavoidably longer than earlier expected. At present, there is neither the justification nor the need to force the prompt delineation of recommendation domains.

Moreover, recent experience is teaching FSR/E researchers that early synchronic perceptions of farming systems provide only partial glimpses of important facets of the farming system. This incomplete understanding of the system can affect the efficient conduct of subsequent research. Failure to address the complexity of the farming system by assuming homogeneity that is unverified is particularly risky when agroecological variability is present or when complex patterns of labor allocation within household units may affect the eventual acceptance of technology. Agroecological variation and intrahousehold dynamics are only a few of the many forms of variability within a system; they cannot encompass all of the potentially important variations that may affect the ultimate appropriateness of a given technology. As long as research is on-going, RDs should be further refined. In our view, however, they ought to be a product of FSR/E, not part of the foundation. The utility of RD is as an extension tool guiding the effective dissemination of technology appropriate to small farm conditions.

Footnotes

[1] Although the IRRI terminology does not utilize the term RD, the land type concept embodies most, if not all, of the critical elements of RDs. See Zandstra, et al., 1981, pp. 9-14.

[2] The verification of RDs through formal and informal surveys may be questioned if the methodology employed implicitly assumes homogeneity of the population in sample selection. See Collinson (1982, pp. 24).

[3] Gilbert, et al. (1980), indicate that the RD definition process is finished with the completion of the exploratory or formal survey.

[4] The relative importance of physical or geographical versus socioeconomic considerations in RD definition is a moot point (cf. Fresco, 1985; Gilbert, et al., 1980; Harrington and Tripp, 1985; Norman, 1980; Weise, 1985). There is a danger of over-generalizing what should be a locale specific, empirical issue.

[5] Hildebrand (1985) appears to make this same distinction in his use of the term "research domain."

[6] See Kirkby, et al. (1982) for a full exposition of this position.

[7] A more complete description of the Quimiag-Penipe Integrated Agricultural Development Project can be found in MAG/IICA (1980).

[8] Farmer strategies of manipulating beans or faba beans in the maize x legume intercrop are further refined once a decision is made to plant beans. Three major local bean varieties are available. Each varies in market value, aggressiveness, and disease susceptibility under excessive moisture. The more marketable but more disease susceptible beans are grown in the lower part of the bean production zone each year. The hardier but less valued beans are grown where it is expected that weather conditions would not favor growth of the other. As actual climatic conditions vary, farmers select the bean variety they believe most appropriate for a given field according to its altitude and climatic conditions in that year.

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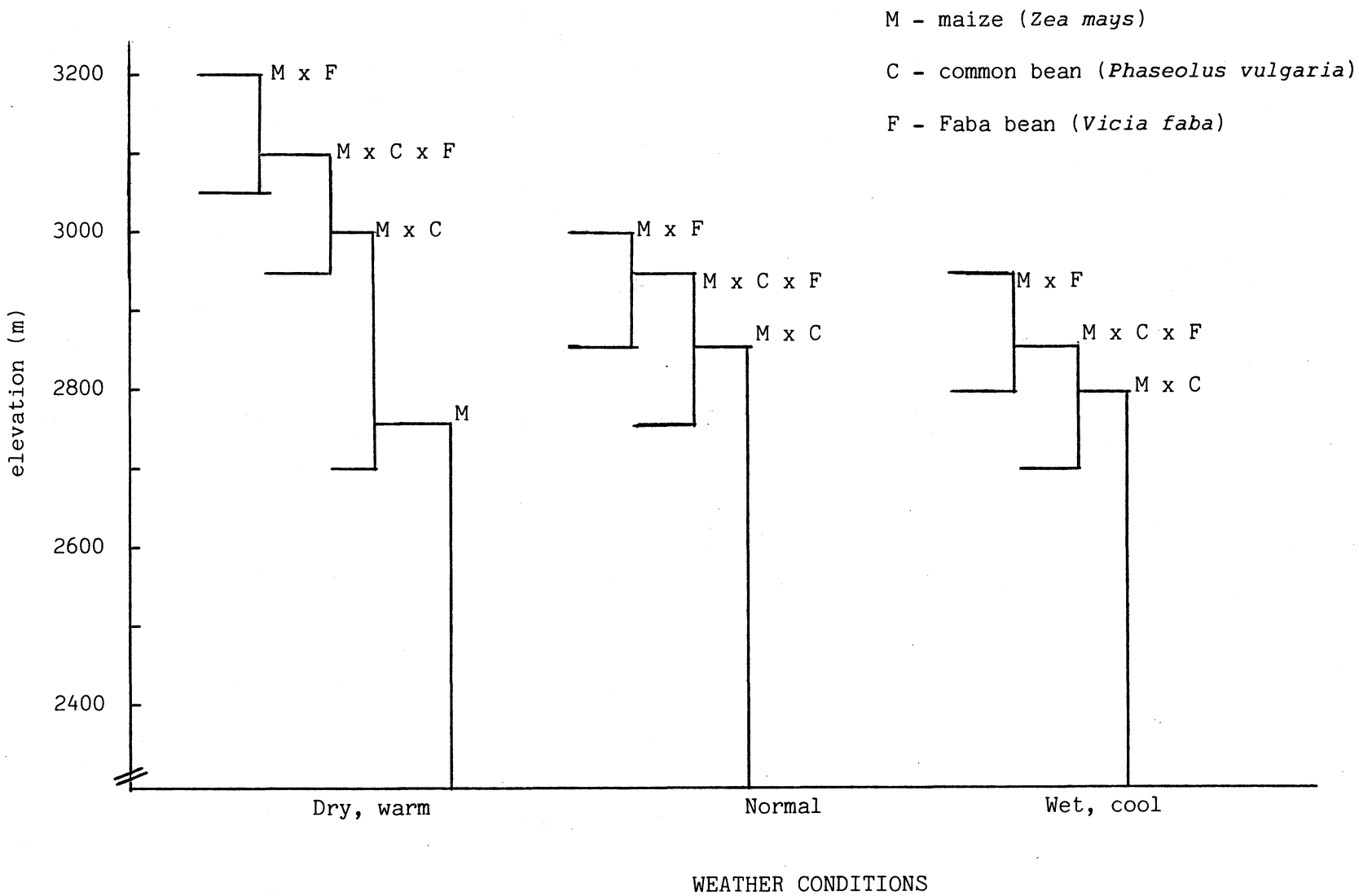
Figure 1. Effect of annual fluctuations in weather upon elevation ranges for the principal maize legume intercropping associations in Quimiag-Penipe.



FACTORS INFLUENCING RECOMMENDATION DOMAIN BOUNDARIES OF THE FARMING SYSTEM AND LEVELS OF AGRICULTURAL DEVELOPMENT IN LUSAKA PROVINCE, ZAMBIA

C. A. Njobvu

INTRODUCTION

The problem of non-adoption of new technologies among small farmers in third world countries has been widely recognized not just as a result of the unwillingness to accept change on the part of farmers and the failure of extension work to carry the message to farmers, but rather due to the inappropriateness of the technologies to the real conditions that exist at the farm level in terms of social, economic, natural, and resource endowment (Shanner, et al., 1982; Mann, 1974). The inability of small farmers to adopt new technologies may reflect weakness in the ability of researchers to produce appropriate technologies. The environment under which small farmers operate plays a major role in influencing decision making in their production activities (Stolen, 1983; Beets, 1982). Recognition of the factors that inhibit the adoption of new technologies had led to the emergence of Farming Systems Research and Extension (FSR/E) as the alternative to developing appropriate technology for small farmers (Shanner, et al., 1982). The rate at which FSR/E is being incorporated into existing research institutions among the third world countries (Collinson, 1985) bears testimony of its importance in developing appropriate technologies that small farmers can adopt.

The procedural requirement for a prior understanding of the farming systems before technologies are developed is an important facet which FSR/E brought into the existing research institutions. This requirement presupposes the fact that development of new technologies without an understanding of the factors affecting farming systems is a resource misdirection, and the developed technology may have limited impact on the system. This paper discusses socioeconomic and agroecological factors considered when drawing the recommendation domains in the province, focusing on their combined effect on management practices and levels of agricultural development.

METHOD OF DATA COLLECTION

Data was collected during the zoning exercise which was aimed at drawing up recommendation domains for Lusaka Province in 1983. The methodology used in carrying out the zoning exercise was based on procedures developed by CIMMYT (Demonstrations of an Interdisciplinary Approach to Planning Adaptive Agricultural Research Programmes) in Central Province, Zambia. The approach differed from the CIMMYT approach in Central Province by interviewing local leaders and key informant farmers instead of only extension workers in order to avoid extension biases.

Secondary data on agricultural aspects, area-wise marketed figures of some major crops (maize, sunflower, and cotton) and input purchases (seed

and fertilizers), were reviewed and this information gave some indication of levels of agricultural development.

TRADITIONAL RECOMMENDATION DOMAINS AND FARMING SYSTEMS IN LUSAKA PROVINCE

The domains are basically two geographical areas representing distinct agroecological zones where farming systems and management practices are different (Table 1). A number of variables determine food production and these include socioeconomic, political, and natural factors, most of which affect the farmer's incentive to produce, and his/her supply of production inputs. They impose limitations on cultivators and determine the geographical pattern and level of farm inputs utilized. In delineating boundaries of recommendation domains for Lusaka Province, the factors considered and examined in relation to geographical areas were: natural, economic conditions, and management practices.

Natural factors affect food production, either postively or negatively. Natural resources available and agroecological differences, such as soil type, water, physical and biological factors, have impact on food production.

Socioeconomic factors are the whole range of economic and political factors which affect the farmer's incentive to produce and his/her supply of production inputs. This group includes what Professor Bunting (1984) calls "the delivery system, policy making bodies, and credit facilities."

Traditional Recommendation Domain One and Two

Traditional recommendation domain one (TRD1) and traditional recommendation domain two (TRD2) are two geographical areas with different natural, physical, and climatical characteristics (Njobvu, et al., 1985) representing two farming systems.

TRD1 covers Chief Shikabeta's area, Chief Mpuka, and Senior Chief Mburuma in Luangwa district, Chief Mphanshya in Rufunsa, and Chief Chiawa in Chirundu. All these areas are located in the northeast, the whole of the eastern part, and southeast of Lusaka province. The areas are characterized by two geographical features which have an effect on the development of agricultural production. These features are the escarpment zone and the valley floor. The escarpment zone is characterized by steep scarp slopes, steep-sided hills, and with some topography comprising the dissected base level of the escarpment zone with small hills and ridges. Soils in this zone are generally shallow, often gravelly, and with frequent rock outcrops. They have no worthwhile arable potential although in some areas villagers have cultivated hilly areas, mainly in sorghum, and this practice is becoming common in Luangwa district.

The valley floor, which comprises both flat alluvial and dissected areas, includes Lunsefwa river valley in Chief Shikabeta's area, Luangwa valley in Luangwa district, and Zambezi valley in Chief Chiawa's area. A

variety of soils are developed on these sediments, including relatively sandy red soils and some alluvial soils. The latter are mostly found along the river basins, which provide fertile areas for crop production although during the rainy season these fields are threatened by floods.

Mountainous terrain and valleys comprise much of the area and, as such, temperatures are quite high. According to Bunyolo (1982), the 24 hour mean temperature regime in these areas ranges from 20 to 25°C. The area lies within agroclimatic zone 1113C. Rain falls between mid-November and March, varying from 700 to 800 mm, except for Runfusa which has slightly higher rainfall (ARPT, 1984). The growing period in this area ranges from 120 to 150 days (Veldkamp, 1983). Tsetse fly in the area has made it impossible for farmers to keep cattle, with most farmers depending on hand hoe for land preparation.

The major drainage system for the area is provided by the Zambezi river in Chief Chiawa's area, Luangwa river in Mpuka and Mburuma areas, Lunsefwa in Chief Shikabeta's area, and Rufunsa river in Mphanshya area. There are river tributaries which provide water during the rainy season in the heart of the area.

TRD2 is geographically the whole western part of the province, comprising the Chongwe, Chipapa, Kasisi, and Mungu areas. The domain is relatively a flat land, with rainfall ranging from 800 to 1000 mm. The soils are mostly a reddish brown clay loam. There are no tsetse flies and the domain has a relatively well developed infrastructural base, which makes it more favorable for agricultural production. Drainage is mainly provided by the Chongwe and Kafue rivers.

PRODUCTION PATTERN AND MANAGEMENT PRACTICES

Peasant farming is synonymous with subsistence agriculture. Both terms refer to one and the same thing, food production mainly for home consumption (Cliffs, 1979). The first goal of any peasant farmer is the provision of subsistence needs (Stolen, 1983). The consideration to sell the little extra is made when he/she has enough food for the year.

The production pattern in traditional agriculture is modeled on meeting the needs of the family. It is characterized by its small size of production. In Zambia, the average farm size is 2.5 ha, while in Chipapa TRD2 it is 2.37 ha and in TRD1 it is 1.2 ha. The range of farm size in the province is 0.25 to 3.5 ha for small farmers, while the farm size for large farmers is more than 40 ha, and for medium-scale commercial farmers it is between 10 and 40 ha (GRZ, 1981).

The main staple food crop grown in TRD2 is maize. Sorghum has been a traditional crop in TRD1, probably as a reaction to low rainfall in the area, although in recent years more than 65% of the area is occupied by maize. This, it appears, is attributed to changing food preferences.

Management practices in TRD1 differ from those in TRD2. In TRD1, small

farmers use a hand hoe for land preparation, planting, and weeding, while in TRD2, ox-plowing for land preparation and planting behind the plow are common among small farmers.

CREDIT FACILITIES AND CROP INCOME LEVELS

Capital scarcity in peasant agriculture is a major constraint for food production in developing countries. The annual crop income level for the majority of small-scale farmers is less than K50 (8.7 U.S. $) (Table 2). The table indicates that more than 76% of the households get an annual crop income of just under K50 per household, and only 8.63% of the households get more than K800.

The problem of credit accessibility for small farmers in Zambia has been well documented (Mansfield, 1976; Klepper, 1976) and according to Due (1978), the average loan that small farmers in Zambia get is just about K254. The Chipapa survey of farmers conducted in 1983 revealed that only 11.5% out of 61 households received loans from the Agricultural Finance Company (AFC) during the 1980/81 season, and 5% of the same number of farmers interviewed received credit from AFC in the 1981/82 season.

DISCUSSION

The environment under which farmers operate is complex. If policies and research programs relevant to particular systems/areas are to be formulated, agricultural researchers and policymakers need to understand the factors that inhibit increased food production and stunt agricultural development. The need for understanding the factors that influence and create different farming systems, which determines different levels of agricultural development, becomes more important in drawing boundaries of recommendation domains. Agroecological characteristics, socioeconomic/resource circumstances, marketing and credit facilities, transport systems, and management practices have influenced the boundaries of RD in Lusaka province. It has to be accepted that an understanding of these factors for drawing RD boundaries is a prerequisite for success in on-farm research and agricultural development. It is possible to find different farming systems under similar agroecological conditions where economic opportunities of the farming community are not the same. On the other hand, it would be hard to find different farming systems under similar socioeconomic circumstances in an agroecological zone. Given equal opportunities in any given agroecological area, management practices tend to conform to these differences, as the two traditional farming systems have shown in Lusaka province. Different farming systems in the province have necessitated different technological interventions, with sorghum (being a drought tolerant crop) as the main commodity for TRD1 and maize for TRD2 in the Adaptive Research Planning Team (ARPT) trial program.

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Table 1. Traditional recommendation domains and their characteristics.

	TRDI	TRD2
Agroecological	Luangwa valley including Shikabeta, Chiawa and eastern part of Rufunsa.	Lusaka West, Kasisi, Chalimbana, and Chipapa.
Main staple crops grown	Mostly sorghum, some maize.	Mostly maize and very little sorghum.
Natural characteristics	Valleys, hilly, tsetse infested; rainfall ranges from 700 to 800 mm.	No tsetse flies, rainfall ranges from 800 to 1000 mm.
Economic characteristics	Weak infrastructural base, poor credit facilities and delivery system.	Adequate infrastructural bases, reliable roads and delivery systems.
Management practices:		
1. Land preparation	Hand hoe.	Ox plow, some by hand hoe.
2. Planting methods	Hand hoe.	Most behind the plow; few by hand hoe.

Table 2. Annual crop income level of farmers in Zambia.

Group	% of H/Holds	Population %	H/H crop income (K)	Per Capita Crop income (K)
1	76.72	65.8	46	4.65
2	14.64	18.1	155	22.80
3	8.63	16.0	805	79.17
All	100.0	100.0	109	19.94

Source: Adapted from the Resources, Activities and Incomes of Rural Households, by A. Marter, in David Honeybone and Alan Marter (eds.); Poverty and Wealth in Rural Zambia, 1979.

DEVELOPING FARMING SYSTEMS FOR SMALL FARMERS IN PARAIBA STATE, NORTHEAST BRAZIL

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INTRODUCTION

The development of farming systems adapted to current conditions, must come from knowledge of the farming systems which farmers have been using for long time.

The structure of farms in Brazil is characterized by the dicotomy latifundium/minifundium. Seventy percent of the farms are minifundiums but they represent only 10.8% of the total area (INCRA, 1972). The small farmers have a great deal of importance in agricultural production. The farms with less than 100 ha represent more than 80% of the total farms,and these farms produce more than an half of the food products (Graziano-da-Silva, 1978).

In Northeast Brazil, the rural population has a predominance of small farmers, 70% of total farms have less than 10 ha, and produce a high proportion of the food crops. The primary sector is one of the main activities in the regional economy of northeastern Brazil, 62% of the active population depends on agriculture.

In 'Brejo Paraibano' region, Paraiba State, Northeast Brazil, the predominant cropping systems is intercropping of subsistence crops, with only a small part of the production marketed. Nevertheless, there are cash crops, such as cotton and sugar cane, the small farmers mainly grow food crops and cotton as a cash crop. The significance of small farmers has a double importance; on the one hand, they ensure the food supply of the rural population, and, on the other hand, they produce basic food for the region.

Until a few years ago, the research approach in Norhteast Brazil followed the pattern of the developed countries or from Southeast Brazil. Therefore, most of the research work was done in isolation from the complex farming systems, mainly looking for answers to the big farmers' problems . The acceptance of new technologies by small farmers has not been taken into account in the design of these technologies. The farms function as a whole, where the different components are interrelated. Therefore, the small farm can be considered as a system, where the physical components (plants, soil, etc.) interact with other external factors (socioeconomics). The specific recomendation for farmers should

know the human being as well as the biological elements of the farm. Research planning should consider the goals of small farmers and the restrictions that they have to reach their targets (Zaffaroni, 1980).

Having in mind these previous considerations the Federal University of Paraiba has begun a cooperative research project with the objective of developing improved farming systems for small farmers in Paraiba State, northeastern Brazil. In adition to the University, the project involves the cooperation of Agricultural Extension Enterprise of Paraiba (EMATER) the Agricultural Research Exterprise of Paraiba (EMEPA), and the Cotton Research Center of the Brazilian Agriclutural Research Ennterprise (CNPA/EMBRAPA). The program utilizes the farming systems approach and involves three distinct phases: 1) the descrptive phase, 2) the design phase, and 3) the test phase. The descriptive phase includes the study of current cropping systems and their environments. The design phase uses the knowledge gained from phase 1 to design new cropping systems adapted to the conditions of small farmers. In the third phase the systems are tested and evaluated under field conditions. Testing includes agronomic as well as socioeconomic considerations.

This paper reports the results of a part of phase one for the municipality of Areia, Paraiba, Brazil.

The specific objectives of this work were: a) to identify and analyze socioeconomic characteristcs of the target groups of farmers, b) to determine the structure of production costs for each social strata, and c) to determine the economic efficiency of the different farming systems through analyses of profitability, and return to the production factors.

MATERIALS AND METHODS

This study was conducted in the municipality of Areia, in the 'Brejo Paraibano' region Paraiba State, Northeast Brazil (Figure 1). Paraiba State has a area of 56,372 square km and the municipality of Areia has 143 square km. Ninty six percent of the farms in this region ranged in size from 10 to 50 ha. The mean rainfall in the region is 1400 mm, the rainfall is concentrated in March and July and is diminishing until end of the year, begining again in January or February. The climate allows a greater variability of crops to grow than in other parts of the state. The topography is rolling and the hills reach heights of more than 600 m above sea level (CEPA, 1977).

A 42-page questionnaire was prepared and applied to 55 small farmers with area less than 50 ha during the 1981 growing season. The farmers usually plant their crops at the begining of the rainy season, January or February. The questionnaires were applied by extensionists of the Agricultural Extension Enterprise of Paraiba State (EMATER). The subjects were divided into 4 strata based upon farm size. These strata were: (I) 0-5 ha, (II) 5-10 ha, (III) 10-20 ha, (IV) 20-50 ha. The information gathered was processed and used to indentify the main socioeconomic charateristcs. Stratification was based on the farm size emploing the methodology of Snedecor and Cox (1956).

From the data gathered the folowing observations were made on: a) social, b) technical, c) marketing, and d) economic aspects. The first three items were analyzed through percentage indicators. The economic evaluation was divided into analysis of the production costs, profitability, and return to the production factors.

The profatibility analysis inclueded computation of:
Family Gross Return (FGR) = total income - cash costs
Net Income (IN) = total income - total costs

The return to the production factors was estimated by:
Return to the capital =(TI - rent - manpower cost - cash cost)/cash cost
Return to the manpower =(TI - rent - cash cost)/ manpower unit
one manpower unit = 8 hours of work
Return to the land =(TI - Manpower cost - cash costs)/ha

The cash cost was computed by adding the amount of money that the farmer spends in cash to produce the crops. The total cost is the summation of fixed costs plus variable costs.

RESULTS AND DISCUSION

Social aspects. The rural population of the municipality of Areia is characterized by farmers directly dedicated to the work of their farms. Eighty percent of the farmers are owners of their land and 20% rent, farm another's land, or work as 'parceiro' or a combination of them (Table 1). Most of the farmers had parents that were farmers too.

Forty per cent of the land was acquired through purchase, 40% through inheritance and 20% through others means. The average farmer worked 8.5 hours per day (Table 2). The age of the farmers varies from 47 to 53. The farmers provide a great proportion of the labor of the farm. The average number of children working on the the farm varies from 2 in stratum I and IV, to 7 in stratum III with stratum II intermediate with 3 children. Most of the children working on the farm are between 8 and 14 years of age. This occurs because when the children reach 18 years most of them migrate to the south and southeast of the country where there are more oportunities to get a job in the larger cities. The lack of manpower in some cash crops, as cacau, has been reported as a consequence of the rural migration (Ramalho, 1978). Ninety one percent of the farmers lived in brick houses and 9% in adobe houses. Among the farmers, 57% had attended primary school, 14% completed primary school, 12% 'MOBRAL' (a special adult education training), 15% were illiterate and 2% had a college degree (Table 3). No trend was noticed regarding size of farms and education. The percent of farmers with primary school completed was the same (7%) in the stratum I and IV. Most of the farmers (80%) did not have other activities and 20 % had other activities.

Technical aspects. Eightyfive percent of the farmers prepared the soil by hand 11% used animal power and hand labor and 4% used tractors and hand labor (Table 4). The most common way of hand soil preparation is

ridges. The farmers that use tractors usually rent them. Tractors are only using in the stratum IV (Table 4).

Of those farmers interviewed, 55% did not utilize any fertilizer, 38 % used manure and 7% organic and chemical fertilizers (Table 5). Forty eight percent used just their own seeds, 11% purchased local seeds, 4% purchased improved seeds, 22% used their own seeds and also purchased local seeds and 11% purchased local and improved seeds (Table 6). The fact that 45% of the farmers used their own seeds has to be considered when developing agricultural programs. Since most of the farmers keep their seeds for the next season, hybrids seeds may not be an alternative in agricultural projects. Primary seed storage was done in bags (67%), in bins (24%), and a combination of these forms (9%).

Cropping systems description. Two main cropping systems were identified: intercropping of cotton/corn/beans and intercropping cassava/corn/beans (Table 8). In the intercropping of cotton/corn/beans, the corn and beans are planted at the same time, at the begining of the rainy season, and the cotton is usually planted after the harvest of the beans. This kind of cropping sytems has been defined as relay intercropping (Andrews and Kassam, 1976). The cotton/corn/beans system is mainly grown in the drier part of the region since cotton is known as a drought tolerant crop to the farmers. The farmer markets the cotton and usually keeps the corn and beans for household consuption. The crops are planted in rows by hand, with the row arrangments varying from farm to farm. The first production phase involves planting beans and corn. Beans are the main crop during this production phase. There usually are 5 or 7 rows of beans between 2 of corn. Once the farmer harvests the beans by hand, cotton is planted, therefore cotton has almost the same row arrangement as beans. However, fewer rows of cotton are planted as this crop has a larger canopy which requires wider row spacing.

In the other cropping system (cassava/corn/beans), there is a lot of variation among the row arrangements used by farmers. Nevertheless, farmers usually grow the three crops at the same time. This kind of intercropping has been reported previously (Mattos and Souza, 1982). The authors state that the simultaneous use of these three crops is a common practice in Brazil. In general, the spaceing of cassava and corn varies from 1.00 m x 0.50 m to 2.00 m x 1.00. Between the rows of cassava and corn, 2 or 4 rows of beans are sown. The farmers usually seed 3 or 4 seeds per hill in order to obtain a good stand.

Marketing. Sixty five of the farmers sold their products on the local market, 27% sold them to intermediaries and 8% sold through other channels (Table 7).

Economic analysis. The cotton/corn/beans system had the higher production cost. In both cropping systems, the manpower cost was the greatest percentage in the structure of the production costs (Table 9). Within manpower the soil preparation is the main labor expense. The most profitable cropping system was cassava/corn/beans (Table 10). This was because this system had higher income and lower production costs than cotton/corn/beans. In the case of intercropping cotton/corn/beans the net

income was negative and more negative in the higher strata. In the case of cassava/corn/beans the higher net income was found in strata I and II. The negative income was due to the fact that the production cost were higher than the income (Table 10).

According to the return to the production factors analysis, the intercropping cassava/corn/beans was more attractive from the capital, manpower, and land investiments returns than the cotton/corn/beans system (Table 11). The return per 'cruzeiro' invested has been higher with the cassava/corn/beans intercropping system. The farmers that used cotton/corn/beans were losing money since the amount of income was lower than investment in cash, therefore there was a decapitalization of the farmer eventhough there was a positive Family Gross Return (FGR). This is because the FGR only considers the cash cost while the Return on Capital also considers rent, and manpower. No trend was observed among the different strata. Furthermore, the return on manpower was higher in the cassava/corn/beans since the income of cotton/corn/beans was lower. As a matter of fact, the cassava/corn/beans system had negative net income-however the manpower requirements were aproximatly the same in both cases (Table 9). The return on land follows the same trend as the other returns and net incomes presented in Table 10.

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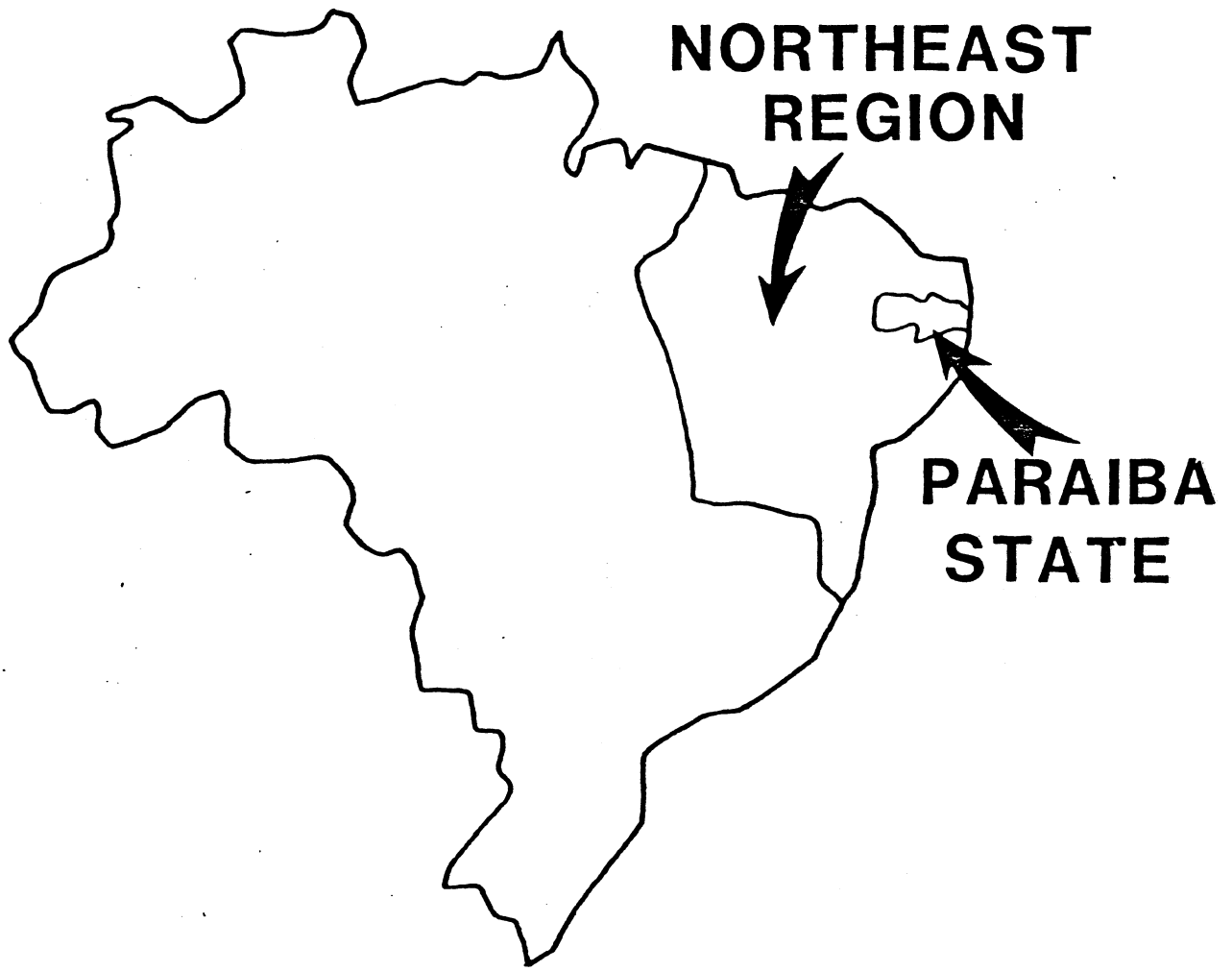

Fig. 1 Map of Brazil showing the Northeast region and Parabia State, where the study was carried out.

Table 1. Relative frequency of different types of farmers in the studied strata, Areia, Paraiba, Brazil, 1981.

Strata	Owner	Renter	'Parceiro'1/	'Morador'2/	Owner and 'Parceiro'	Owner and Renter	Total
I	40	-	4	2	4	-	49
II	7	4	2	2	-	-	16
II	11	-	-	-	-	2	13
III	22	-	-	-	-	2	24
Total	80	4	6	4	4	4	100

1/'Parceiro' a person that works another's land and shares the production with the owner of the land. Usually, half of the production is for the 'parceiro' and half for the owner.

2/'Morador' a person that lives in another's land , takes care of the land and also farms for himself.

Table 2. Mean age of the farmers , mean of work hours per day , mean number of children per family , and mean of children that work in the farm , in the diferent studied strata, Areia, Paraiba, Brazil, 1981.

Strata	Mean age of the farmers	Mean of work hours per day	Mean number of children/fam.	Mean of child. work in farm
I	52	8	4	2
II	53	9	3	3
III	50	9	5	7
IV	47	8	5	2

Table 3. Relative frequency of the education level of the farmers in the studied strata, Areia, Paraiba, Brazil, 1981.

Strata	Illiterate	'MOBRAL'	Primary School incompleted	Primary School completed	College degree	Total
I	11	7	24	7	-	49
II	-	2	13	-	-	15
III	4	2	7	-	-	13
IV	-	2	13	7	2	24
Total	15	12	57	14	2	100

Table 4. Relative frequency of the forms of soil preparation, in the different studied strata, Areia, Paraiba, Brazil, 1981.

Strata	By hand	Animal Labor and manual	Tractor and manual	Total
I	47	2	-	49
II	15	-	-	15
III	11	2	-	13
IV	13	7	4	24
Total	85	11	4	100

Table 5. Relative frequency of the type of fertilizer used by the interviewed farmers, Areia, Paraiba, Brazil, 1981.

Strata	Manure	Chemical	Manure and chemical	Nothing	Total
I	20	-	2	27	49
II	9	-	-	5	15
III	9	-	-	4	13
IV	16	-	5	2	24
Total	55	-	7	38	100

Table 6. Relative frequency of seed origen in the different strata, Areia, Paraiba, Brazil, 1981.

Strata	Own	Market	Improved	Market and Own	Own and improved	Market and improved	Total
I	27	9	-	2	11	-	49
II	5	2	2	4	2	-	15
III	5	-	-	2	5	-	13
IV	7	-	2	-	4	11	24
Total	45	11	4	8	22	11	100

Table 7. Relative frequency of the different channels of marketing, Areia, Paraiba, Brazil, 1981.

Strata	Intermediaries	Local Market	Other Channels	Total
I	16	33	-	49
II	2	13	-	15
III	-	9	4	13
IV	9	11	4	24
Total	27	65	8	100

Table 8. Distribution of the main farming systems of the interviewed farmers, Areia, Paraiba, Brazil, 1981.

Strata	Intercropping cotton/corn/beans	Intercropping cassava/corn/beans	Total
I	35	15	50
II	9	5	14
III	7	5	12
IV	15	9	24
Total	65	35	100

Table 9. Production costs (in cruzeiros/ha) of the two main cropping systems identified, Areia, Paraiba, Brazil, 1981.

Items	Intercropping cassava/corn/beans	(%)	Intercropping Cotton/corn/beans	(%)
Manpower	20879	70	20539	67
Inputs	5876	20	5421	18
Interest	1940	7	3380	11
Rent of the equip.	1000	3	1119	4
Total	29695	100	30459	100

The values are means of the 4 analyzed strata

Table 10. Production costs (PC), net income (NI), and family gross return (FGR), in cruzeiros/ha, of the two main farming systems, Areia, Paraiba, Brazil, 1981.

Strata	Intercropping cassava/corn/beans			Intercropping cotton/corn/beans		
	PC	NI	FGR	PC	NI	FGR
I	25510	11693	32219	39984	-13369	19043
II	21893	-3831	11059	22327	-8117	11002
III	23624	9287	28991	30871	-18555	5453
IV	35770	11853	40023	28648	-23299	-3161

Table 11. Returns to the production factors for the farming systems cassava/corn/beans (cass/c/b) and cotton/corn/beans (cott/c/b), Areia, Paraiba, Brazil, 1981.

Strata	Return to the capital 1/		Return to the manpower 2/		Return to the land 3/	
	cott/c/b	cass/c/b	cott/c/b	cass/c/b	cott/c/b	cass/c/b
I	-174	209	135	387	-9576	12502
II	-248	-43	130	162	-5546	-2985
III	-204	260	56	387	-14524	10210
IV	-249	159	-59	357	-20172	12050

1/ In cruzeiros
2/ Cruzeiros/unit of 8 hours
3/ Cruzeiros/ha

INTRAHOUSEHOLD ISSUES IN DIAGNOSIS

Andree Rassam

Anna Kajumulo Tibaijuka

FARM LABOR BY AGE AND SEX IN NORTHWESTERN SYRIA: IMPLICATIONS FOR TWO PROPOSED TECHNOLOGIES

Andree Rassam

BACKGROUND AND OBJECTIVES

The International Center for Agricultural Research in the Dry Areas (ICARDA), seeks to make improvements in the principal groups of food commodities, viz., cereals, food legumes, forages, and livestock, as well as the farming systems in which they are dominant. With the introduction of innovations on the farm, other changes are expected to occur. To optimize the beneficial effects of these innovations, scientists in the Farming Systems Program (FSP) conduct studies to assess the impact of new technologies. Biological and social scientists interact and have high sensitivity in considering farmers' needs. Two of the objectives of the research activities in the Food Legume Program in ICARDA are:

1. Selecting lentil cultivars suited to mechanical harvesting.

2. Introducing new varieties of chickpeas which are resistant to ascochyta blight and thus, suitable for early sowing.

Previous research at ICARDA had shown that new mechanical technologies were rather quickly adopted in Syria. For instance, since the first introduction of tractors to Syria in the 1940s, land preparation is now a task almost completely done by tractor. In addition, combine harvesters are becoming increasingly common in both wheat and barley. All the legume crops are hand harvested and ICARDA is currently developing a mechanical harvester for legume crops. It is known that hand harvesting is laborious, time consuming, and costly but, on the other hand, it is an opportunity for those who seek off-farm employment. This source of income may be important for many rural households.

A first attempt was made to examine the constraints faced by the farmers in lentil production through a survey of 115 lentil growers in 52 villages in Syria. The survey was conducted jointly by the Food Legumes Improvement Program and the Farming Systems Program of ICARDA in 1978/79 and 1979/80. Some interesting findings (ICARDA, 1982, and unpublished results) are presented below:

- The main factor limiting yields as seen by the farmers is the weather; almost 90% of farmers find that inadequate and variable rain is a serious constraint. Insufficient fertilizer and weed infestation are also considered constraints. In addition, almost 50% of farmers' lentil plots were affected by orobanche, an endemic parasitic weed of legumes.

- Although labor is expensive, farmers do not seem to have a problem in hiring labor. Almost 80% of farmers did not find problems in hiring labor. It is believed that farmers plan in advance to

organize the harvest labor since the period for harvesting lentil crops is quite limited.

- Sixty-four percent of farmers reported that they would not drop lentils, knowing that lentil plays an important role in crop rotations. In addition, the straw which is a valuable source of animal feed is an important component of the total revenue in lentil production. In some years, lentil straw is more valuable than the grain.

- Farmers are sensitive to the economics of lentil production: a fall in the price of lentils and a rise in the cost of harvesting would play a role in their decision-making about lentil production. Twenty-six percent of farmers said they would increase their lentil areas if any increase in lentil price occurred.

- Female labor plays an important role in lentil harvesting. Ninety-three percent of the growers used both male and female labor, and in 60% of the cases female labor was dominant. Information on whether the labor input is provided by the household, hired, or both, was not studied in detail.

The second objective mentioned above relates to one of the interesting research results to date at ICARDA. It is the development of new chickpea cultivars that are resistant to cold and to ascochyta blight. The Kabuli chickpea is considered an important food legume in most of the Mediterranean basin due to the beneficial role it plays in rotations and in human diets. Chickpea is usually a spring crop and is planted in March. Farmers plant it late in order to avoid ascochyta blight which is likely to attack a crop sown in December or January. Research has shown that if the disease can be avoided, increased moisture availability to the plants can increase yields tremendously (Keatinge and Cooper, 1982). From intensive research and on-farm testing, it has been demonstrated that a new variety, planted in winter, results in nearly a 100% increase in yield over the local variety (ICARDA, 1982). Spring planting allows late cultivations before sowing to provide relatively good weed control, but this does not occur with winter plantings; thus, in order to achieve these yield responses, two intensive weedings are required. Information is needed to find out: (1) would it be convenient for the household to plant chickpea in wintertime?, (2) would the household be able to mobilize the additional labor for the weeding task?, and (3) by whom would the weeding tasks be carried out?

Since any new technology may create a diversification and/or displacement of labor use, rural development programs should consider the contribution of the principal sources of labor input when new technologies are introduced in rural communities. Hence, the welfare of farm families would be enhanced in a more balanced manner when possible social impacts are examined in any agricultural development.

Based on this need, drawing a picture of the division of labor between men, women, and children in agricultural production is one aspect of this

research, and examining the social impact of the two technologies under development at ICARDA is the second.

Specifically, the objectives are:

1. To determine the tasks of men, women, and children related to various crop production activities.

2. To compare men's versus women's labor input.

3. To predict the potential impact that new technologies will create vis-a-vis labor uses.

METHOD OF THE STUDY

The Study Unit

The study unit in the analysis is the household, defined as the group of people who normally eat and reside together, provide labor on the farm holdings, and share income and resources. The household might include nuclear or extended families. Persons who are away from the main residence on a temporary or partial basis are considered part of the household if they continue to share in the household economy.

Period and Location of the Study

The study investigates farm labor for the production of crops and livestock for the 1982/83 cropping season. Since the new technologies refer to the food legume crops, the sampling locations were selected on the basis of the distribution of chickpea and lentil production areas. In 1980/81, almost 30% of the area planted to these legumes in Syria was in Aleppo Province of northwestern Syria (SAR, 1981). This percentage represented the highest in Syria. Aleppo Province is divided into eight districts. The location of the sample was chosen in the Azaz district (north of Aleppo) for two reasons:

1. In Azaz district two agroclimatic zones (1 and 2) are found.[1] Due to the fact that winter sowing would allow the new cultivar of chickpea to be introduced in lower rainfall zones, it was decided to include villages from zone 2 in the study.

2. Adding up the area planted to lentil and chickpea, 40% of the area devoted to these crops in Aleppo Province is located in Azaz district (Table 1).

SAMPLE SELECTION

The total population of Azaz district is 127,488 (SAR, 1981). Two villages were selected from the Azaz centre sub-district in zone 1 and two other villages were selected in zone 2 from the Aktarine sub-district, from a

total of 34 and 54 villages respectively in the two sub-districts.

The selection of villages was based on a certain representativeness within each zone, under the following criteria:

a. Ratio of the total households to farms is about equal to one in the village, thus there are few landless households;

b. Cropping systems representative of the area;

c. Similarity in soil and climate, and

d. Common ethnic backgrounds.

A list of the households was provided by the head (*mukhtar*) of each selected village. The total number of households in the two selected zone 1 villages is 116 households (41 in Yahmoul village and 75 in Jarez village). The total number of households in the two selected zone 2 villages is 102 (51 in Al-Ghose village and 51 in Al-Barouzeh village).

Twenty-four households were randomly selected to represent each zone (12 in each village). This sample size was regarded as sufficient under the practical assumption that overall variations are not great within each zone in the sampled area (ADC, 1976). Systematic random sampling was used in selecting the sample from the lists of households.

The total sample is 47 households; one household was dropped since it neither owned land nor participated in off-farm agricultural activities. The sample comprises 21% of the total population in the chosen villages.

The villages selected in zone 1, Jarez and Yahmoul, are located 50 to 55 km northwest of Aleppo. The main crops of these two villages are wheat, barley, legumes (including lentil, vetch and chickpea), and summer crops. They receive an average rainfall of between 400 to 500 mm per year. The villages in zone 2, Al-Barouzeh and Al-Ghose, are located 45 to 50 km northeast of Aleppo. The main crops of these two villages are wheat, barley, lentil, vetch, and summer crops. Virtually no chickpeas are being grown by farmers in these villages. These two villages receive an average rainfall of between 300 to 350 mm per year.

DATA COLLECTION

Several steps were taken before starting the formal interview process. First, during the fall season in 1982, informal visits were made to different villages in different agroclimatic zones. General questions were asked concerning division of labor by sex in different tasks for each crop in on-farm and off-farm agricultural activities, other economic activities, and decision-making regarding aspects of farm household life.

Visits were made after selecting the four villages in order (1) to explain the study to the village leader, (2) to get a list of village

households from him, and (3) to find out if the households were willing to cooperate.

A structured questionnaire was prepared and in January 1983, pretest interviews were conducted in two different villages having the same agroclimatic zones (1 and 2) as the villages studied. Finally, the formal survey started. The information was gathered in three rounds, spaced in time over the cropping season, for each household according to the different tasks carried out at each time. Information was collected from both the husband and wife in each household at each interview session.

The first round of interviews started February 16, 1983. About an hour was spent in each household and approximately three households were interviewed each day. The focus of the first interview was:

1. The demographic structure including household composition by age and sex, education, enrollment at school, age at marriage, and work residency.

2. The crops planted in the current season and all the specific tasks already carried out such as the tillage operations, seeding, fertilizing, and rodent control for the winter crops. The following questions were asked for each crop:

   - The amount of land the household allocated to the crop.

   - The specific tasks that have been carried out prior to the interview. For each task and each crop, information was collected on who performed the tasks, disaggregated by sex and age, the methods used, the approximate date of accomplishment (month and week), and duration as total number of days and total number of hours per day. Wage questions also were disaggregated by age and sex.

The second round of interviews began at the end of April. This interview concerned cropping techniques and livestock management. More specifically, the following tasks were examined:

- Planting and fertilizer application for the spring and summer crops;

- Controlling weeds either manually or chemically;

- Using pesticides and controlling rodents, and

- Livestock activities.

The livestock questions comprised: (1) kind of livestock owned; (2) feeding practices; (3) herding practices; (4) processing animal products; (5) marketing; and (6) to whom the receipts from livestock products accrue.

The third and final round of interviews was conducted in late August

after the harvest and all the post-harvest tasks were completed. The questions sought to provide information on the following activities:

- Harvesting;
- Transporting the crop from the fields to the threshing floor;
- Threshing;
- Winnowing;
- Cleaning, and
- Bagging.

Questions on the proportions of income derived from crops, livestock and off-farm agricultural and non-agricultural activities were asked. Because information on total income is difficult to gather, only the proportions of income derived from different sources were determined. The validity of the responses for income were checked against the land owned, number of livestock, number of people working outside, and those working in off-farm agricultural activities.

General questions were also asked concerning the attitudes of husbands and wives toward the proposed new technologies.

THE FINDINGS

Following the analysis of this survey, general conclusions can be drawn which are of importance to both of the new technologies under consideration.

1. Specialization of agricultural tasks by household members, and by hired labor, differs among crops and techniques used in accomplishing the tasks. From Table 2 to Table 5 one can notice that land preparation and chemical weed control are usually done by men. Fertilizer application and seeding are generally male tasks, but spreading manure in the field is normally done by females. Hand weeding and planting summer crops are mostly done by females. Seed preparation and the various steps in the harvest process seem to be shared jointly by male and female labor, although there is also specialization by sex within the harvest process itself.

2. In general, men's and women's contributions to agricultural labor (in terms of hours of physical work, including both family and hired) are almost equally divided. Women's contribution is 50% of the total hours spent in all production whereas it is 43% for men and 7% for children (Table 6).

3. Women provide 62% of all labor for legume crops and 42% for cereal crops, compared to 27% and 54% provided by men. Legume crops

involve more nonmechanized operations in which women's contributions exceed those of men.

4. Hired labor is equally divided by sex in total agricultural production, but . . .

5. The contribution of hired labor, by sex, to agricultural production depends on the degree to which the production is mechanized (Table 6, cereal vs. legume crops).

6. Considering total agricultural production, household labor provides 59% of the total work-hours, while the rest is provided by hired labor. It appears that in the villages surveyed, the shortage of hired labor does not constitute a problem.

7. Fifty-seven percent of the adult (13 years and older) household labor input is provided by women.

8. Household labor, primarily women, plays a major role in the hand weeding task for the legume crops. The household contribution to this task is 81%.

9. Women and children provide 87% of the work-hours while men provide 13% of the total labor input for harvesting legume crops.

10. Two-thirds of the labor input in harvesting legume crops are provided by hired labor. Women and children provide 94% of hired labor.

11. Labor hired from outside the village comes from villages where an average of 40% of total households are landless.

12. On the average, a household owns 16 ha of land and the main source of income comes from crops and livestock (63% of the total income), while 10% and 27% come from agriculture off-farm and non-agricultural activities respectively.

DISCUSSION AND CONCLUSION

It is clearly shown that women play a major role in hand weeding and harvesting in agricultural production. Therefore, changes in labor use in these two particular tasks might have profound and radical effects, since the two technologies discussed earlier are closely linked with labor use in these tasks. First, mechanical harvesting of legumes might halt or reverse the reduction in area planted to legumes as well as decrease the burdens on household labor, but will eliminate a source of employment for women and children and may have a negative effect on the incomes of the poor and landless rural families. The survey shows that diverse male job opportunities are offered in and outside the villages while female job opportunities are restricted to agricultural activities.

Improving the welfare of rural farm families is inseparable from the employment opportunities of rural women. If we assume that mechanization is to increase the welfare of rural farm families and decrease the burden of hand harvesting, alternate opportunities of employment are needed for these women who are likely to be displaced. In addition, agricultural off-farm income among the villages studied is low compared to other sources of income. The question that can be raised here is, whether agricultural off-farm income is important to the rural families in the villages which mainly provide the hired labor. Thus, further survey work which focuses on sources of income for small landholders and landless households is needed to evaluate and measure the income effect of the mechanization of harvesting legume crops.

The second point, which is relevant to the improved variety of chickpeas, relates to the fact that successful introduction of winter sown chickpea will depend on additional weeding. Both husbands and wives were questioned on their willingness to adopt this new practice based on two assumptions: first, that a winter sown crop would double their current yield, but second, it would need an intensive weeding in early spring. According to the results of this interview, in zone 1, 70% of the households, both husbands and wives agreed that they would grow the new variety. Twenty-five percent of them were prepared to pay for the additional hand weeding and thought that this extra cost would be worthwhile. In the remaining households, both husbands and wives indicated that household labor would be used to carry out the weeding. Most of the wives agreed to undertake this extra task if yield increases from winter sowing were as great as suggested. Thirty percent said they would not grow the new variety because of the labor expenses. In these households, family labor could not be provided to carry on this task due to the household composition. Hence, the new variety would only be adopted among those households if herbicides became available.

In zone 2, three groups of answers were found. In the first, 63% of the households stated that they would grow the new variety, but thought that the payment for the intensive weeding might be problematic. These villages are, relatively speaking, less well off than the villages in zone 1, and none of the households were accustomed to paying for weeding since the farmer's wife and daughters usually perform that task. The idea of having a good yield of chickpea interested both the husband and wife. The second group (29% of the households) refused to plant the new variety due to lack of land, and the third group (8% of the households) reported contradictory answers between husband and wife; the husbands refusing while the wives appeared willing to do the extra weeding.

In conclusion, it can be said that earlier planting will increase the weed problems on the chickpea plots, and hand weeding tasks in these plots will weigh most heavily on women in the household. The fact that most weeding is currently done without hiring labor indicates that there is no labor bottleneck at this time of the cropping calendar, but a greater weeding effort may overtax a family's female labor pool. On the other hand, household composition and the family demographic structure might have an effect on cropping choice, hired labor practices, and choice of

technologies. If chemical weed control of chickpeas is introduced, this task will be undertaken by the men and this will radically affect the labor allocation in chickpea production. Whether such a change would be good or bad for rural households depends on: (1) the alternate uses women make of their time, and (2) the importance of weeds in feeding livestock.[2]

I have argued in this paper that the new technologies under development at ICARDA would have an effect on labor use, particularly on women's labor, since the proposed technologies are closely linked with the tasks carried out by them. Further studies are needed in order to determine the cost and the benefit of these changes.

Footnotes.

[1]Syria may be divided into five agricultural zones (SAR, 1983):

1. Zone 1: With annual rainfall between 350 to 600 mm and not less than 300 mm in two-thirds of the years. The main crops are wheat, chickpeas, lentils, and summer crops. Fruit and olive tree growing is important.
2. Zone 2: With annual rainfall rate between 250 to 350 mm and not less than 250 mm in two-thirds of the years. The main crops are wheat, barley, lentils, and summer crops.
3. Zones 3, 4, and 5 are drier and only minimally engaged in legume production.

[2]Another study, titled "Wheat Dominated Systems in Syria," by ICARDA's Farming Systems Program, is currently in progress. Its objectives include an assessment of farmers' fertilizer and weed control practices. It also aims to estimate the proportion and importance of weeds in animal diets.

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Table 1

Total area of lentils and chickpeas in Aleppo Province, 1980/81.

Districts	TOTAL Area (ha)	TOTAL %	LENTIL Area (ha)	LENTIL %	CHICKPEAS Area (ha)	CHICKPEAS %
Azaz	16,853	40.0	11,711	41.5	5,142	30.0
Afrin	9,723	23.1	2,364	8.4	7,359	52.9
Al-Bab	1,731	4.1	1,725	6.1	6	0.0
Manbej	25	0.1	25	0.1	--	--
Jarablus	311	0.7	311	1.1	--	--
Ein Al-Arab	517	1.2	463	2.6	54	0.4
Jabal-Sama'an	10,295	24.5	8,963	31.8	1,332	9.6
Al-Sfireh	2,667	6.3	2,653	9.4	14	0.1
TOTAL	42,122	100.0	28,215	100.0	13,907	100.0

Source: Statistical Abstract Statistics for Aleppo Province 1982, Central Bureau of Statistics, Syrian Arab Republic.

Table 2

Contribution of men, women and children as the percentage of hours spent in legume production.

Agricultural Activities	% Hours Spent in Each Task	MH	WH	CH	MHV	WHV	CHV	MHO	WHO	CHO	Total	Total Contributions M	W	C
Tillage Operations	3.7	32	0	0	22	0	0	46	0	0	100	100	0	0
Seeding	1.5	30	14	0	25	0	0	31	0	0	100	86	14	0
Fertilizer use	0.9	49	19	0	13	0	0	19	0	0	100	81	19	0
Hand weeding	16.1	12	63	6	1	18	0	0	0	0	100	13	81	6
Pest and Rodent Control	2.5	51	29	0	11	0	0	9	0	0	100	71	29	0
Harvesting	58.4	9	22	3	1	26	4	3	24	8	100	13	72	15
Transport	5.3	36	26	0	36	0	0	2	0	0	100	74	26	0
Threshing	6.6	27	37	13	13	0	0	10	0	0	100	50	37	13
Winnowing	1.6	48	9	0	41	2	0	0	0	0	100	89	11	0
Cleaning	2.4	34	66	0	0	0	0	0	0	0	100	34	66	0
Bagging	1.0	44	56	0	0	0	0	0	0	0	100	44	56	0
Total	100.0	16	30	4	6	18	2	5	14	5	100	27	62	11

Source: Villages surveyed in study.

MH = men from household
WH = women from household
CH = children from household

MHV = men hired from village
WHV = women hired from village
CHV = children hired from village

MHO = men hired from outside
WHO = women hired from outside
CHO = children hired from outside

M = men
W = women
C = children

Table 3

Contribution of men, women and children as the percentage of the total time spent in cereal production.

Agricultural Activities	% Hours Spent in Each Task	MW	WH	CH	MHV	WHV	CHV	MHO	WHO	CHO	Total	Total Contributions M	W	C
Tillage Operations	10.1	32	0	0	27	0	0	41	0	0	100	100	0	0
Seeding	5.1	19	14	0	26	0	0	41	0	0	100	86	14	0
Fertilizer use	11.0	31	21	0	17	0	0	30	0	0	100	78	21	1
Herbicides use	0.8	20	5	0	0	0	0	75	0	0	100	95	5	0
Hand weeding	20.6	5	87	8	0	0	0	0	0	0	100	5	87	8
Rodent control	8.5	54	27	0	19	0	0	0	0	0	100	73	27	0
Harvesting	26.2	9	35	6	11	17	4	14	3	1	100	34	55	11
Transport	12.0	34	16	0	40	0	0	10	0	0	100	84	16	0
Threshing	4.6	34	37	2	27	0	0	0	0	0	100	61	37	2
Winnowing	0.4	47	17	0	36	0	0	0	0	0	100	83	17	0
Cleaning	0.4	21	61	0	6	12	0	0	0	0	100	27	73	0
Bagging	0.2	66	34	0	0	0	0	0	0	0	100	66	34	0
Total	100.0	22	37	3	17	4	1	15	1	0	100	54	42	4

Source: Villages surveyed in study.

MH = men from household
WH = women from household
CH = children from household

MHV = men hired from village
WHV = women hired from village
CHV = children hired from village

MHO = men hired from outside
WHO = women hired from outside
CHO = children hired from outside

M = men
W = women
C = children

Table 4

Contribution of men, women and children as the percentage of hours spent in summer crop production.

Agricultural Activities	% Hours Spent in Each Task	MH	WH	CH	MHV	WHV	CHV	MHO	WHO	CHO	Total	Total Contributions M	W	C
Tillage Operations	11.1	24	0	0	29	0	0	47	0	0	100	100	0	0
Planting & replanting	20.0	18	57	0	0	24	0	0	1	0	100	18	82	0
Thinning, weeding and loading	27.0	36	62	2	0	0	0	0	0	0	100	36	62	2
Cutting tops and thinning fruit	24.0	75	24	1	0	0	0	0	0	0	100	75	24	1
Fertilizer uses and irrigating and furrowing	3.0	91	9	0	0	0	0	0	0	0	100	91	9	0
Spraying insecticide, fungicide & guarding	2.0	27	57	16	0	0	0	0	0	0	100	27	57	16
Harvest and transport	13.0	33	41	18	0	0	8	0	0	0	100	33	41	26
Total	100.0	42	40	4	3	5	1	5	0	0	100	50	45	5

Source: Villages surveyed in study.

MH = men from household
WH = women from household
CH = children from household

MHV = men hired from village
WHV = women hired from village
CHV = children hired from village

MHO = men hired from outside
WHO = women hired from outside
CHO = children hired from outside

M = men
W = women
C = children

Table 5

Contribution of men, women and children as the percentage of hours spent in tree crop production.

Agricultural Activities	% Hours Spent in Each Task	MH	WH	CH	MHV	WHV	CHV	MHO	WHO	CHO	Total	Total Contributions M	W	C
Tillage Operations	16.0	23	0	0	27	0	0	50	0	0	100	100	0	0
Planting & hilling	22.0	19	62	0	15	4	0	0	0	0	100	34	66	0
Pruning & gathering	35.0	57	30	0	9	0	0	4	0	0	100	70	30	0
Hoeing, irrigating & fertilizer use	24.0	78	8	0	14	0	0	0	0	0	100	92	8	0
Pest control and fungicide	1.0	6	83	0	0	0	0	11	0	0	100	17	83	0
Weeding and thinning	2.0	21	79	0	0	0	0	0	0	0	100	21	79	0
Total	100.0	47	28	0	14	1	0	10	0	0	100	71	29	0

Source: Villages surveyed in study.

MH = men from household
WH = women from household
CH = children from household
MHV = men hired from village
WHV = women hired from village
CHV = children hired from village
MHO = men hired from outside
WHO = women hired from outside
CHO = children hired from outside

M = men
W = women
C = children

Table 6

Contribution of men, women and children as the percentage of the total time spent in on-farm agricultural production.

Contribution	Cereals	Legumes	Summer Crops	Trees	Total
A. Household					
Men	22	16	42	47	24
Women	37	30	40	28	32
Children	3	4	4	0	3
Sub-total	62	50	86	75	59
B. Hired from Village					
Men	17	6	3	14	11
Women	4	18	5	1	12
Children	1	2	1	0	2
Sub-total	22	26	9	15	25
C. Hired from Outside					
Men	15	5	5	10	8
Women	1	14	0	0	6
Children	0	5	0	0	2
Sub-total	16	24	5	10	16
D. Grand Total					
Men	54	27	50	71	43
Women	42	62	45	29	50
Children	4	11	5	0	7

Source: From villages surveyed in study.

INTRA-HOUSEHOLD RESOURCE ALLOCATION CONSTRAINTS IN THE IMPLEMENTATION OF THE BANANA-COFFEE DEVELOPMENT PROGRAM IN THE KAGERA REGION, TANZANIA

Anna Kajumulo Tibaijuka

INTRODUCTION

While inter-household variables such as economic stratum are now widely recognized to have important influence on the success of agricultural production programs in Africa, little attention has been given to intra-household variables such as gender issues. The household continues to be treated as a homogeneous production unit without internal conflicting interests and varying objectives. It is assumed that all members of a household would react and benefit equally and uniformly from a given rural development program such as a credit or extension intervention.

Experience has proved this assumption to be wrong. Quite often, the homogeneity of a household unit is superficial or only outward. Internally, control of and access to the factors of production is usually vested in the male members of the household (Bader, 1975; Okeyo, 1980; Wylie, 1981; Tibaijuka, 1985). This situation reduces the significant contribution of African women in farming to merely "laborer" rather than "farmer" status. Further, it suggests that as a "labor" class, the interest of rural women in individual households could be significantly different and even conflicting from those of men who often own and control the means of production. It follows that unsuspecting rural development programs often aggravate the disadvantaged position of women in households, thereby worsening rather than improving their welfare. Mbilinyi and Mascarenhas (1984) quote numerous examples in hoe culture where mechanizing plowing operations alleviate the burden of men while increasing that of women at weeding and harvesting periods. Kamuzora (1983) discusses how the introduction of perennial crops such as tea for male farmers resulted in the worsening of female welfare by pushing their annual crop farming activities to marginal areas further away from villages, thus lowering their average productivity.

To the extent that an individual's response to a given development program is highly influenced by the expected benefit, it can be hypothesized that in households where status and privileges are highly dependent on gender, female and male farmers are likely to respond differently and benefit unequally from various development programs. At a community level, these differences could have significant impact on the success or failure of a given community development program. This article explores the degree to which the exclusion of intra-household variables, notably the gender issues, have had on the implementation of the ongoing banana-coffee development programs in the Kagera region of Tanzania.

THE BANANA-COFFEE FARMING SYSTEM

The cultivation of bananas and coffee in Tanzania is the exclusive domain of peasant farmers. Production is concentrated in 4 of Tanzania's 20 regions.

It is estimated that about 4 million people (20% of the population) derive at least 50% of their daily intake of calories from bananas. Coffee is the country's leading export, earning about 30 to 35% of the total foreign exchange annually.

In the study area, peasants interplant the two crops; bananas cover about 75% of the area and coffee the remaining 25%. The average size of a peasant plantation is about 0.5 ha, although significant variations exist both within and between geographical areas depending on the economic stratum of a household and the area's population density. In the densely populated areas, the average size of a banana-coffee holding is 0.2 ha, or half the 0.4 ha estimated as the minimum size required to fully support an average family of 5 people (Raid, et. al., 1975).

It follows that the farming system is also characterized by the cultivation of supplementary annual food crops, including beans, cassava, sweet potatoes, and maize, by women. Table 1 summarizes the results of a recent (1982-1983) labor utilization survey on 200 banana-coffee farms in Kagera region. It can be ascertained that women spent about 25% of the daylight hours on annual crop farming compared to the men's 5%. Altogether, women contributed 87% of the labor input in annual crop farming and 46% labor input in plantation farming.

In the Kagera region, the prevalence of couch grass (*Digitaria scalarum*) and the infertility of the soils due to leaching from excessive rain have resulted in high labor and manure requirements to establish banana-coffee plantations. The total investment to establish a plantation was estimated at T.Shs.23,740/= (US $1396) per ha in 1983 (Tibaijuka, 1984). Individuals unable to hire labor and purchase manure can only afford to make modest expansions of the plantations in the course of a lifetime (Friendrich, 1968). On the other hand, the maintenance of the plantations, if done routinely, is less exacting than the cultivation of annual crops on the infertile grasslands. Therefore, in this farming system, ownership of a banana-coffee plantation by a peasant household is of paramount importance. The plantation is a capital asset with which to raise the average productivity of farm labor, thus ensuring oneself a higher standard of well being in the future. It is for this reason that peasants in this region and in many other banana-coffee cultures in Africa are generally economically better-off than their counterparts in annual crop systems. The banana plant has the additional advantage of acting as a soil and microclimate regulator, thereby improving soil fertility and, through intercropping, enabling the cultivation of important supplementary crops such as beans and yams where they otherwise could not grow.

PRODUCTION PROBLEMS AND DEVELOPMENT PROGRAMS

In the 1970s, a significant decline in both the quality and quantity of coffee was experienced in Tanzania as a result of a general decline in marketing services coupled with falling producer coffee prices in the face of an increasing cost of living. For example, the real coffee producer price in 1978 had declined by 32.4% compared to that of 1968 (Ellis & Hanak,

1980). In response to these massive reductions in real price levels, coffee producers started to neglect and even to uproot the crop or to move from coffee to other forms of economic activities. Mean coffee yields on peasant farms reached all time low levels of about 200 kg ha^{-1} compared to 810 kg ha^{-1} obtained on estates.

To counter this unsatisfactory trend, the government, with assistance from the EEC (European Economic Community), launched a Coffee Improvement Program (CIP) at a total cost of U.S. $20.8 million, which started in September 1977 and ended in October 1981 (Ministry of Agriculture, 1980). This was then followed by the second phase of the project called the Coffee Development Program (CDP). It started in October 1982 and will end in October 1985. This project is estimated to cost U.S. $18.4 million (Ministry of Agriculture, 1983). The aim of the two programs is to improve coffee quantity and quality among smallholders who produce about 95% of the total production. This has been done through the provision of extension services, inputs, and the improvement of marketing services.

As a result of the CIP, standards of pruning and husbandry were reported to have improved throughout the country's main coffee producing areas, with the exception of the Kagera region. The official reasons for the failure of the CIP in this particular region were given as (1) the fact that coffee is only a supplementary rather than a major source of farm income in the area; (2) poor program implementation in the zone; (3) processing problems in the local coffee factory; (4) dislocation caused by the 1978-1979 war with Uganda, and (5) the smuggling of appreciable quantities of coffee to neighboring countries (Ministry of Agriculture, 1983).

While these reasons are important and valid in explaining the failure of the CIP in the Kagera region, microlevel studies trying to study the problem at household level arrived at different findings altogether. A comprehensive farm management study by Tibaijuka (1983) established that the main cause of the failure of the program was increasing food shortage in the area. As a result of prolonged banana pest problems (weevils and nematodes), yields had declined between 20 to 90%. Food shortage was increasing and (1) necessitating the uprooting of coffee in order to free land for additional cultivation of bananas or other supplementary food crops, and (2) causing the diversion of labor, especially female labor, away from coffee to the cultivation of extra food crops outside the banana-coffee plantations. Tibaijuka concluded that coffee improvement would depend on first eliminating the food shortage problem in the area by controlling banana pests. She recommended that instead of a single commodity approach, a farming system approach aiming at improving the performance of the 2 main crops simultaneously be launched.

In response to this recommendation, the government and the EEC decided to supplement the CDP with a 3-year parallel Banana Pest Control and Improvement Program (BPCIP) starting September 1984. The project will cost U.S. $2.2 million and is conceived as a pilot scheme which could further be developed into a long-term development program for the whole country if it would be deemed necessary after the first phase. The project components

include the conventional strengthening of research, extension, and input supply for the crop (Ministry of Agriculture, 1983).

INTER-HOUSEHOLD VARIABLES

Inter-household variables such as income differences and their influence on access to inputs by farmers are discussed in both the coffee and banana development programs. In the coffee development program, all farmers are guaranteed access to inputs, as these are supplied without cash payments. The cost is recovered through a levy by the official single channel marketing authorities. There being no formal marketing system for bananas and so no means to recover credit when sales of bananas are made, it was decided that inputs for bananas must be purchased directly by the farmer on cash terms. The poorer farmers unable to pay the price for pesticides are given the alternative approach to control the pests through trappings and changed cultural practices, which are being promoted through the extension component of the program.

INTRA-HOUSEHOLD VARIABLES

In both crop development programs, there is no discussion whatsoever on intra-household issues such as the status and different roles played by men and women in the farming system and on how these could impinge on the efficient implementation of the programs. The rest of this article will therefore analyze this issue more closely. The purpose is to show how the omission of these issues might affect the implementation and effectiveness of the ongoing interventions.

Women's Access to the Factors of Production

Most female farmers in Africa occupy a subordinate position in the traditional socioeconomic and political systems (Boserup, 1970; Fortman, 1979). The situation of women is generally much worse in perennial crop cultures like the one being discussed. This is because of the permanency of the plantations, which has evolved extremely conservative values and thinking. Male interests are often deeply entrenched. As pointed out above, in the Kagera region, the establishment of the plantation is costly. It follows that the access of individuals to banana plantations is usually through inheritance. A patrilineal land inheritance system operates. Farms are passed on from father to son. Only in exceptional circumstances do farms go to daughters. Married women cannot inherit farms from their husbands and have no legal right to the property. Thus, despite the considerable labor input by women on the plantation, bananas and coffee are regarded as men's crops (Table 1). Married women have no direct access, let alone control over the plantations. Their tenure is highly insecure. Upon divorce or in the case of widowhood in childless marriages, women end up returning to their original childhood homes, thus losing access to the banana farms they have been maintaining or that they may even have established in their married life. This eviction occurs without compensation and the victim might have been married for over 50 years!

Obviously, the insecurity of land tenure rights to women is a disincentive for women, who make up 57% of the labor force on the plantation, to make long-term investments and to come up with new innovations to increase productivity (Tibaijuka, 1979). Development projects seeking to improve the output of bananas and coffee, as those reviewed above, must seek to grant secure land tenure rights to women. Only then can women be truly motivated and innovative in adopting the new husbandry recommendations. The present modest contribution of women in the establishment of the plantations (24% of the labor) is partly explained by the insecurity of tenure, which reduces their incentive to undertake long-term investments. Of course, the heavy nature of the operations at establishment and women's overcrowded daily schedules compared to men also come into the picture, but are not the most important factors (Table 1).

Crop Improvement and Women's Welfare

The role played by women in banana-based societies to produce supplementary food crops is worth further attention. Table 1 shows that women spend 25% of the daylight hours on these crops compared to the men's insignificant 5%. Overall, women contributed 87% of the total labor input in annual crop farming for the sample. It is rather obvious that the smaller the banana plantation relative to family size, the greater the need for women to produce supplementary food crops. Therefore, women in poorer households (in terms of the size of the banana farm and its yields) have the greatest burden to feed their families.

Thus, by reducing banana yields, pests have increased the burden of women to produce supplementary food crops and have therefore worsened their welfare. One would therefore expect that measures which would restore banana productivity must benefit women significantly. Ironically, this has not necessarily been the case. The recommended practice to control both banana and coffee pests has been increased use of pesticides. Injudicious use of pesticide has in turn been shown to have disturbed the ecological balance on the plantation, thus causing an outbreak of bean attacking millipedes and snails. Traditionally, beans interplanted by women on the banana plantation are the second most important staple in the region. An outbreak of bean pests on the plantation has therefore forced women to cultivate beans or their substitutes on the infertile grasslands, thus decreasing female labor productivity. Most women cannot cultivate sufficient quantities of beans outside the plantation due to shortage of labor for land preparation. This operation is omitted when beans are interplanted on the plantation. Nutritional standards, especially protein intake, are on the decline.

The Division of Labor

The main reason explaining the differential impact of development interventions on men and women as discussed in the preceding section is the traditional distinct sex-based division of labor. Table 2 provides a summary of this division of labor. It can be observed that men's duties on the farm are literally restricted to only a few operations; everything else is women's responsibility. This traditional division of labor has been

rightfully identified as one of the greatest bottlenecks to increased agricultural production in the area (Friendrich, 1968; Swantz, 1977; Moody, 1969; Tibaijuka, 1984). Particularly notable is the fact that the division of labor and associated social values and norms limit the possibilities for men to be fully employed on the farm, especially because the opportunities to expand the plantations do not exist due to land shortage. At the same time, female labor is scarce. The final outcome is a total lower output for the entire household.

To quantify the economic loss caused by the traditional division of labor, linear programming (LP) was used to develop production plans for 3 farm model situations. All factors were held constant except the pattern of the division of labor. In the first scenario, the traditional division of labor was strictly adhered to. In the second scenario, the emerging pattern where food shortage has already necessitated that men assist women to produce supplementary food crops is assumed. Table 2 also shows this emerging pattern. Finally is the generalized division of labor scenario. This is the idealized situation where it is assumed that the sex-based division of labor would be entirely abandoned, thus allowing the total labor source in the family to engage in highly profitable enterprises regardless of sex. The outcome of the 3 scenarios on net income and productivity are summarized in Table 3 below. The production plan is for an average farm of 0.5 ha of plantation crops and 3.21 labor equivalents. The household has the option to take up seasonal paid employment off the farm.

Table 3. The effect of liberalizing the division of labor on farm income and productivity on smallholder banana-coffee farms in the Kagera region, Tanzania.

Division of labor scenario	Net farm income (shs)	Return to land (shs ha^{-1})	Return to labor (shs ha^{-1})	Return to capital (%)
Traditional	51843	3008	6.10	18
Liberal	53949	3465	6.84	30
Generalized	56891	2718	7.03	26

As expected, the traditional division of labor showed the lowest net farm income and the lowest returns to labor. A generalized or non-distinct division of labor was the most profitable in terms of farm gross income and return to labor. This analysis proves that by merely abandoning the traditional division of labor, farm incomes could be improved by up to 10% and productivity of labor and capital by up to 15% and 44% respectively. It is therefore within the interest of the whole household to adopt a more generalized division of labor.

CONCLUSION

The paper has examined the consequences of having excluded intra-household variables in designing the Banana-Coffee Development Programs on smallholder farms in the Kagera region of Tanzania. It is argued that the scoioeconomic benefits of the programs have been significantly limited by the insecurity of land tenure rights for the main actors, namely women. Although women presently perform most of the farm operations in maintaining the plantations, they have no direct access or control over these farms. This is due to the prevalence of a patrilineal land inheritance system arising out of customary laws.

Tenure insecurity prevents women from fully benefiting from their labor and taking an active role in the development of the plantations. The granting of land tenure rights to women is seen as a prerequisite for the maximization of socioeconomic benefits from future research and extension interventions. Using linear programming, an analysis of the economic costs of the division of labor is made. It is established that under a traditional sex-based division of labor, household incomes are lower than under a generalized division of labor regime. Labor and capital productivity also can improve by 15% and 44% respectively if the traditional division of labor regime were to be replaced by the generalized one. It is strongly recommended that educational programs and campaigns to promote liberalization of the division of labor should supplement the ongoing purely technical interventions.

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Table 1. Summary of male and female labor input in various activity categories on smallholder banana-coffee farms in Kagera region, Tanzania.

Activity Category	As % daylight hours			As % total labor input in activity			Male vs. female labor input level of significance where F-test done (p)
	Men	Women	All	Men	Women	All	
Maintenance of plantation	23	21	23	48	52	100	NS
Expansion of plantation	7	5	6	76	24	100	.001
TOTAL PLANTATION FARMING	30	26	29	54	46	100	NS
Annual crops	5	25	16	13	87	100	.0001
TOTAL CROP PRODUCTION	35	51	45	39	61	100	.001
Livestock rearing	6	.6	3	89	11	100	.0001*
ALL FARM PRODUCTION	41	52	48	43	57	100	.013
Brewing banana beer	1	.5	.6	58	42	100	
Marketing farm products	2	.1	.3	72	28	100	
ALL FARMING ACTIVITIES	44	52	49	43	57	100	
Wage Employment	3	--	1.5	97	3	100	
Building, handicraft & skills	2	1	1	68	32	100	
Trading and other	1	.5	.3	69	31	100	
TOTAL ECONOMIC ACTIVITIES	50	53	52	45	55	100	
Domestic activities	4	23	16	14	86	100	.0001
Funeral and mournings	4	4	2.5	40	60	100	
Educational and political	2	.4	.3	41	59	100	
Sicknesses	3	4	3	40	60	100	NS
TOTAL LABOR UTILIZED	63	84	74	36	64	100	
LEISURE TIME	37	16	26	--		--	

Source: Computed from Survey Data, February 1982-March 1983.
* Tested only on households owning cattle.

Table 2. Summary feature on traditional and emerging division of labor between men and women in Kagera region, Tanzania.

TYPE OF OPERATION	BANANAS	COFFEE	TEA	BEANS[1]	GNUTS	BNUTS	MAIZE[1]	SORGHUM	MILLET	CASSAVA[2]	POTATOES	COCOYAM[2]	YAMS[2]	CATTLE	GOATS
TRADITIONAL DIVISION-CROPS															
Land preparation	Mf	Mf		F	F	F	F	Mf	F	F	F	F	F		
Planting	M	M		F	F	F	F	MF	F	F	F	F	F		
Weeding	Fm	Mf		F	F	F	F	FM	F	F	F	F	F		
Applying manure		M													
Pruning	M	M													
Cutting mulch	F	Mf													
Mulching	Fm	Mf													
Scaring birds							Fm	MF	F						
Harvesting	Mf	MF		F	F	F	F	MF	F	F	F		F		
Processing & Storage		MF		F	F	F	F	MF	F	F	F		F		
Marketing	Mf	Mf		Fm	Fm	F		M	F	F	F		F		
TRADITIONAL DIVISION-ANIMALS															
Grazing														M	Mf
Cutting grass-feed/bedding														Fm	Fm
Milking														Mf	
Diverse activities														Mf	Mf
EMERGING TREND - CROPS															
Land preparation	MF	Mf		Mf	Fm	Fm	F	Fm	MF	F	Fm	Fm	Fm		
Planting	M	M		Mf	F	Fm	F	Fm	MF	F	Fm	Fm	F		
Weeding	FM	MF			F		F				FM	FM	F		
Apply manure/fertilizer	M	Mf		M											
Apply insecticides	M	Mf		M				Mf							

Table 2. (continued)

TYPE OF OPERATION	BANANAS	COFFEE	TEA	BEANS[1]	GNUTS	BNUTS	MAIZE[1]	SORGHUM	MILLET	CASSAVA[2]	POTATOES	COCOYAM[2]	YAMS[2]	CATTLE	GOATS
Pruning	M	M		M											
Cutting mulch	FM	Fm		Fm											
Mulching	FM	FM		MF											
Scaring birds[3]								Fm	MF	F					
Harvesting	FM	FM		MF	F	F	F	Fm	MF	F	Fm	Fm	Fm	Fm	
Processing	FM	FM		Fm	F	F	Fm	MF	F	F					
Storage		FM			Fm	F	F	Fm	MF	F	F				
Marketing	Mf	Mf		MF	Fm	F	Fm	Mf		FM	Fm	Fm			

Source: Field Survey, February 1982-March 1983. Also see Friendrich, 1968, (p. 1971).

M - Male; F = Female.

A capital letter shows the sex with main responsibility. A small letter indicates sex assisting. Two capital letters mean equal responsibility.

1. Interplanted on plantation by women. The operations shown are for non-plantation cultivation, i.e., grassland.
2. Interplanted on plantation by any sex. Operations refer to non-plantation fields as in (1).
3. Men also participate in hunting of wild animals at village level.

ON-FARM TRIALS

Randloph Barker and Clive Lightfoot

David Gibbon

FARM EXPERIMENTS ON TRIAL

Randolph Barker and Clive Lightfoot

INTRODUCTION

A year ago, we argued that practitioners of FSR should pay more attention to the development of appropriate methodologies. We decided at that time to focus our effort on the methodologies used in farm field experiments, in particular experiments that involve cooperation among researchers and farmers. We believe that these trials, which fall between standard trials conducted by research workers and demonstrations that are managed and implemented by extensionists and/or farmers, are a distinctive feature of FSR.

To assess on-farm field trials, we developed a questionnaire (see Appendix II) to investigate common practices, problems, and successes of FSR projects around the world.

Questionnaires were mailed to approximately 120 projects throughout the world. Projects were chosen through mailing lists or from personal contacts. All were identified as Farming Systems Research type projects. Forty-one responses were obtained - 18 from Africa, 16 from Asia, and 7 from Latin America. The titles and location of the forty-one projects are shown in Appendix I.

The questionnaires were not quantitatively analyzed because the nature of the sample and the questionnaire itself did not allow this. This is because the terminology and language of farming systems is confusing and differs among practitioners in various regions of the world. Not all respondents interpreted terms in the same manner, which was perhaps as much the fault of the authors as the respondents. Also, researchers working on the same project answered some of the questions very differently. For these reasons, we use considerable caution when making propositions about the nature of experimentation in farmers' fields and at this time can draw no firm conclusions.

In this paper we describe the range of on-farm experimental methods used in the farming systems research projects of our survey respondents. Methods are appraised in terms of the problems that occur when projects try to fulfill FSR objectives and employ FSR concepts. The series of propositions with which we conclude lay the groundwork for further dialogue among FSR practitioners. In short, we see the analysis of this survey as part of an on-going study of FSR methodology.

DESCRIPTION OF ON-FARM TRIALS

This section describes five key parts of on-farm trials based on survey responses:

1. Basic project structure and mandate.
2. Nature of trial management.
3. Research focus of trials.
4. Trial designs.
5. Interaction with farmers.

1. Basic Project Structure

While it is extremely difficult to identify the resource endowments associated with specific projects, some patterns do emerge. Most projects had five research sites or less. The sites were chosen because of environment, crops grown, or production potential. Politics entered into the choice in several cases. While the African projects had about one MS/PhD level researcher per site, the Asian projects had approximately two MS/PhD level researchers per site. Crop sciences dominated the interdisciplinary mix by a wide margin. Several projects had no social scientists and/or no animal scientists. It seems likely that many of the so-called Farming Systems Research projects are really Cropping Systems Research projects. In fact, the titles of at least half of the forty-one projects (see Appendix I) suggest that they have a cropping systems orientation or, in some cases, an even more narrow focus. All of the projects were conducting experiments in farmers' fields.

2. Nature of Trial Management

A key factor in an analysis of field experimentation concerns the nature of the trial management since this gives a clear indication of the degree of farmer involvement. Table 1 shows the types of trials identified according to management: researcher managed and implemented (RMRI), farmer-researcher managed and implemented (FRMI), and farmer managed and implemented (FMFI). Thirty-two projects conducted researcher-managed trials, 32 conducted farmer-researcher managed trials, but only 19 conducted farmer-managed trials. In the majority of projects (14 out of 21), experiments were conducted using two or all three of the above management formats. On eleven sites, both researcher - and farmer-researcher managed experiments were conducted, and on thirteen sites all three levels of management control were being used.

In projects where more than one level of management control was exercised, researchers tended to equate researcher- managed trials as technology

generating, farmer-researcher managed trials as technology verifying, and farmer-managed trials as technology extending. In most instances, this sequential process was not strictly adhered to and, in a few cases, all three types of management modes were simultaneously employed. This simultaneous approach seems logical given the fact that technologies are frequently in different stages of development and testing.

3. Research Focus of Trials

Most researcher-managed trials dealt with component technologies such as varietal trials, fertilizer experiments, weeding experiments etc. The trials can generally be characterized as exploratory, or site specific, or both. In most instances, the objective was technology generation.

Many of the farmer-researcher managed trials focused on cropping patterns, particularly sequential cropping patterns, and intercropping. This was especially true among the Asian projects. However, there were also a significant number of trials that dealt with component technologies. The farmer-researcher managed trials were described for the most part as either regional or site specific. In the majority of these trials, the objective was technology verification.

In the few cases where farmer-managed trials were used, characteristics and objectives varied too widely to generalize.

4. Trial Design

Trial design factors include ranges in the number of treatments, in the number of replications on farm, the number of replications across farm (i.e., each farm site serves as a replication), and in the size of plots. We expect these factors to differ from what one normally encounters at an experiment station, but also to differ according to the nature of trial management. For example, experiment station trials typically have many treatments, three or four replications, and plots of about five square meters in size. One would expect to find more replications in trials conducted in farmers' fields due to considerably greater variability in the environment, although these replications may occur both on the farm and across farms. Also in part due to greater variability, one would expect to find larger plots with trials involving farmer management than one normally finds at the experiment station. However, on farms it is much more difficult for researchers to judge the correct number of replications and plot size.

The researcher-managed trials typically ranged in number of treatments from 4 to 12 with 3 to 4 replications on farm and 3 to 4 replications across farms (each farm site serving as one replication). In a few projects, the number of replications across farms was considerably larger. Plot sizes typically ranged from 20 to 200 square meters.

There were generally fewer treatments in the farmer-researcher than in the

researcher-managed trials, but 3 to 4 treatments were common. Replications on farm varied from 1 to 4 in most projects. However, replications across farms followed a bimodal distribution, with several projects having from 1 to 5 replications and an almost equal number of projects having from 5 to as many as 20 replications. There also appears to be a bimodal distribution in plot size, with several projects having plot sizes, of 200 square meters or less and several others having plot sizes of 500 to 1000 square meters or more. Projects with large plots tended to have fewer replications across farms. Larger plots also tended to be associated with cropping pattern trials as opposed to experiments dealing with specific components.

Most of the farmer-managed trials involved a single, unreplicated treatment on-farm, but with a varying number of replications across farms. Plot sizes also varied widely, but tended to be large, 500 square meters or more.

5. Interaction with Farmers

Regardless of the type of management control exercised, most respondents indicated that farmers were chosen to participate in a project because of their willingness to cooperate. In only 3 or 4 projects was any sampling procedure used as a basis for selecting cooperators. Respondents also indicated that nearly all cooperators were representative of the target group.

Farmer involvement in the experimental process itself varied with the type of management control. In researcher-managed trials, the farmer was normally involved in evaluation, less frequently involved in the decisions made throughout the cropping season, and seldom involved in decisions on treatments to be used. Researchers normally made all of the decisions regarding the timing of operations - planting date, treatment applications, etc. They also provided seeds, treatment inputs, and labor for many operations.

From the perspective of farming systems research, the farmer-researcher managed trials are potentially the most interesting because of the opportunity for mixing the scientific knowledge of researchers with the experiential knowledge of farmers. We asked respondents whether farmers played a nominal, a consultative, or a decision-making role in the design and management of trials. That is to say, did researchers actively consult with farmers who then implemented management operations, or alternatively were the farmers involved in trial design. Most respondents reported that farmers played a consultative role. Consultation in this trial type was apparently broader than in the case of the researcher-managed trials; with most projects reporting that farmers were consulted on treatments to be used, timing of operations, and the evaluation of results. Researchers provided seeds and treatment inputs for experiments and, in some cases, part of the labor. In the majority of cases, they played an important role in management decisions. One is left with the impression that, in their consultative role, the farmers are not full partners in the decision-making process.

As noted previously, less than half of the projects reported conducting

farmer-managed trials, and there appears to be much greater variability in the design and management of these trials than for the other two management categories. Farmers were clearly involved in the decision-making and evaluation process, but in a few cases researchers continued to exercise strong control over management decisions.

APPRAISAL OF EXPERIMENTAL METHODS

In this section, we highlight several key problems and successes that researchers experienced with their on-farm trial methods particularly in relation to FSR principles.

Problems Encountered in Execution and Analysis of Trials

Respondents were asked to indicate the most serious problems they encountered. These include over extension, lack of trained manpower, lack of logistical subsidization of farmer cooperators, problems in obtaining reliable data from experiments and in analyzing the data, problems related to design and layout of trials, lack of appropriate technology, and lack of communication with farmers.

The most commonly mentioned problem was 'over extension,' which seemed to be a problem in at least half of the forty-one projects reporting. Some sample comments are as follows:

> "Over extension!!! Trying to cover too much ground at one time."
>
> "Too ambitious in trying to use too many sites." (In this case eight).
>
> "Trying to stretch resources too thin over too big an area"
>
> "Set yourself reasonable targets which can be achieved within your resource base as management is the key factor in success, and when a program is stretched to complete its task, management and control suffer substantially reducing output."

Closely linked to over extension is the issue of resource availability. Respondents commented on the adequacy not only of physical resources but also of human resources:

> "Lack of trained technicians." (Not surprisingly, the need for training was frequently mentioned).
>
> "Inputs such as fertilizer and chemicals not readily available when needed. Lack of vehicles/ motorcycles used in monitoring experiments. Delay in release of research funds."

"Logistical support (vehicles, fuel, personnel) is critical. Make sure that it is there and guaranteed."

"Delay in release of funds; no one assigned at the beginning to purchase inputs; delay in arrival of inputs."

The consequences of over extension, inadequate logistical support, and lack of trained manpower is an inability to get field trials properly established. Over half of the projects reported problems in obtaining the needed seed, getting the crops planted on time, or getting a high rate of germination. Many reported problems in all three areas:

"Seeds don't come on time, especially those from international centers."

"We unfortunately don't have good seed storage and need to check the germination percentage and overseed accordingly."

"Formidable logistical problems in getting all trials out on time."

"Farmers agree to prepare land but fail to do so by agreed upon time."

Some respondents were concerned about the subsidization of farmer cooperators:

"We should not make farmers interested in getting subsidies (monetary help)."

"It is easy for participatory farmers to develop a dependency on researchers for inputs over time."

"Jealousy on the part of non-farmer cooperators has contributed to the intentional destruction of experiments."

Somewhat less than half of the projects reported problems with obtaining reliable data from experiments:

"We have deemed it necessary to conduct experiments on the methodology of taking crop cuts."

"Loss of data is very common in on-farm trials. Farmers can decide to perform certain operations that were not in the plan."

"Trying to collect too much irrelevant information."

About a third of the project had problems with data analysis. The most frequently mentioned problems were with economic as opposed to agronomic analyses, which in part reflects the lack of economists on several of the project teams:

"There is a problem with tests not designed for statistical analysis which are on large plots."

"No problem with agronomic analysis of trials now that we have our own microcomputer and MSTAT."

"No economist for the first two years"

"Price information is difficult to obtain and secondary sources of price data are questionable."

"Labor input data are almost impossible to get."

A range of methodological problems were encountered in the design and lay-out of trials:

"Avoid complicated trials."

"Start with a few simple trials when dealing with new researchers who come from extension."

"Distinguish clearly between experimentation and demonstration results."

"Decide if more experiments on a wide range of crops should be undertaken at the expense of more replication and accuracy in a fewer number of trials."

"Data from on-farm experiments is generally not as reliable scientifically, but it gives a good insight into the real problems faced by farmers and therefore has more value than just results in a notebook."

"The major limitation in our approach was the high variability among farmers making it difficult to obtain statistically analyzable data. The objective of obtaining such data and of obtaining farmer acceptability should be treated in separate trials as much as possible."

A number of respondents commented on the lack of appropriate technology and the tendency to rely too much on research station technology:

"Overconfidence in the application of research station results to farmers' circumstances."

"Trying to test a complex technological package requiring highly specific operational implementation."

"Avoid approaching farmers with a ready made solution to his problems and production constraints."

Lack of communication with farmers (and with other disciplines and agencies) was an issue in several projects:

"Still insufficient farmer (and extension) participation and discussions in developing the trial program."

"Avoid designing trials without understanding farmers well and without farmers' participation."

"Do talk to farmers first and find out the real situation existing in the area."

Points That Contributed to the Success of Trials

It is frequently easier for practitioners to identify problems and faults with projects than to identify their successes. We asked respondents to comment on the most successful points in their trials. Many of the answers were mirror images of the problems identified in the previous section, e.g. keep experiments simple, don't overextend, keep a close supervision on trials. But there were a number of comments that were sufficiently different to be worthy of mention:

"Use of indigenous farmer knowledge."

"Open-mindedness to accept criticisms, especially from farmers."

"Farmers were able to sense that they could teach us many things, and we tried to encourage this to the point that they could take over the extension part of the process by teaching other farmers."

"Initially trials should not be too rigid and should enable some flexibility to enable farmers' modifications to be incorporated."

"Admitting a line of experiments wasn't working and dropping it."

"Changing the agronomic design to facilitate the work of social scientists."

"Good informal integration with extension with many

trials being run by extension."

"Establish good relations with local extension personnel, involve them in everything, credit them with success, accept failures yourself."

"Involving research station scientists from the very beginning."

"Team interaction and clear definition of technical and supportive responsibilities."

"Took the whole experimental program as a tool for village development."

"The fact that we realized that improving production has to be completely integrated with improved access to processing capacity, marketing programs, and national economic policy."

Respondents emphasize several points in the above comments. These include: close interaction with farmers, with extension and with the research station; flexibility in the design of experiments; a clear definition of responsibilities; and a notion that appropriate design and execution of experiments will require knowledge about conditions not only on the farm, but also in the community, in the markets, and at the national level with respect to policy.

PROPOSITIONS

We have listed some of the broad problems and successes reported in recent FSR trials throughout the world. However, we need to look more closely at the implications that can be drawn from our survey for future research, particularly as they apply to farmer-researcher managed trials. As we noted at the beginning of this paper, many of the projects included in this survey have a more narrow cropping systems type focus. Further, many FSR projects conduct researcher-managed trials or use farmer trials for extension purposes alone. Although such projects may legitimately be labeled FSR, they do not strengthen links between research, extension and the farm. Without the bridge of farmer-researcher managed research, a hallmark of FSR, information cannot be freely channeled backward and forward for meaningful results.

We know that many of our colleagues would prefer that farmer-researcher managed trials, those that we consider optimum for FSR research, be called researcher managed - farmer implemented. The survey results themselves suggest that this is what is happening. However, to achieve anything beyond limited success represented by data in a notebook, there must be a meeting ground between researcher control over management for experimental integrity and farmer participation.

The majority of projects using research managed-farmer implemented trials complain of major difficulties in obtaining useful results. What appears to be wrong? Based on survey results, we would like to set forth some

propositions or hypotheses as a basis for further discussion at this conference.

1. Many projects are handicapped because they do not have the breadth of focus and the proper interdisciplinary mix to be properly characterized as farming systems research. The agencies conducting the research may not have the mandate to take on a broader focus. To what extent does a crop focus and or lack of social scientist predicate failure?

2. Experimental objectives and methods still seem to be strongly linked to conventional agronomic research at the experiment station. That is to say, trials are laid out using standard statistical techniques to determine to what degree crop yields can be increased by improved varieties, higher levels of inputs, and better husbandry practices. System interactions are ignored, as are many issues not directly related to yield, especially those involving risk. Do we need to move away from the more conventional yield maximizing focus of traditional agronomic experiments and if so, what are more appropriate objectives and designs?

3. The experimental procedures in most farmer-researcher managed trials tend to be top down, with decisions regarding design, treatments, and trial management made principally by the researcher, sometimes without even consulting the farmer or obtaining only a perfunctory OK from the farmer. In farmer-researcher managed trials, farmers need to be involved directly in the design process to be sure that we are addressing the right problems and that we take into account the experiential knowledge of the farmer. How extensively should farmers be involved in the management process, and how best can we achieve farmer involvement?

4. Many projects are overextended or alternatively lack adequate logistical support. There is a tendency to be too ambitious and to set goals that are not in keeping with the limited manpower and resource inputs of the project. We must pay attention to logistical and technical details, such as getting seed and inputs delivered and crops planted on time. How should the delivery of inputs be managed?

5. As a consequence not only of overextension but also faulty methodology, many projects are awash with data from experiments that cannot be analyzed using standard statistical and economic procedures to yield meaningful results. Here we must pay attention to methodological issues related to field design such as proper definition of farmer controls, adequate replication across farms, and appropriate plot sizes. In this regard, are standard statistical designs and analyses appropriate for farmer-researcher managed trials or are there better alternatives?

6. All too frequently extension is not involved from the beginning in FSR projects and hence a barrier is established between extension personnel and FSR project personnel. What should be the role of extension workers in facilitating FSR field experiments?

7. There has been a tendency to assume that 'on the shelf' technology already exists and that the main goal of experimentation in farmers' fields is technology verification. More often than not, this is a false

assumption. But it has been difficult to build the strong link between FSR personnel and experiment station researchers necessary to ensure feed-back of farmers' basic research needs. How can we best involve experiment station researchers in back-up research to support FSR?

8. A handful of farmers are chosen largely on the basis of willingness to cooperate in trials. Often these farmers are supplied with inputs over a considerable period of time, while little attention is given to involving the majority of the target group. What are the implications for on-farm trial procedures that would allow the involvement of many more farmers?

Let us remind the reader that our objective in identifying some of the good and bad features of field experiments is to ask how we can improve the effectiveness of the research process. The results of our survey of FSR practitioners discussed in this paper lead us to no hard and fast conclusions.

In order to understand more clearly the relevance of the eight propositions we have listed above, we have sent a brief follow-up questionnaire to all FSR projects that we initially contacted. We are asking respondents to tell us for their project whether each of the eight propositions is a) very relevant, b) relevant, or c) not relevant. This will help us in formulating meaningful conclusions.

Table 1. Experiments Being Conducted in Farmers' Fields in Forty-One Research Projects Throughout the World Classified by Management Controls.

Type of Management Control	Number of Projects Reporting
RMRI only	5
FRMI only	6
FMFI only	1
RMRI + FRMI	11
RMRI + FMFI	3
FRMI + FMFI	2
RMRI + FRMI + FMFI	13
TOTAL	41

RMRI = Researcher-Management and Implementation

FRMI = Farmer-Researcher Management and Implementation

FMFI = Farmer-Management and Implementation

Appendix I

Region & Project No.	Project Title	Location	Date Begin	Source of Funds	Contractor	Unit in Charge
Latin America and the Caribbean						
1	Adaptive Agri. Research on Cassava and Rice in the Dominican Republic	Dominican Republic	1981	Wageningen Univ. (Holland)	Dept. of Rural Soc. Wageningen Univ.	Wageningen University
2	Tropical Root Crops and Plantain Systems	Nicaragua, Costa Rice, Panama	April 1983	IDRC	Tropical Ag. Research and Training Center (CATIE)	CATIE
3	Farming Systems Research and Development	E. Caribbean	July 1983	USAID, Caribbean Res. & Develop. Inst. (CARDI)	CARDI	CARDI
4	CIAT/British Mission Cropping Systems Project	Northern Colonization, Cresent, Santa Cruz, Bolivia	Sept. 1983	Nat'l Development Overseas Aid	------	Centro de Investigicion Agricola Tropical, Santa Cruz
5	Agricultural Development Support II (ADS II)	Haiti, West Indies	June 1984	USAID	Univ. of Arkansas Winrock Int'l.	University of Arkansas
6	Cropping Systems	Jamica	Nov. 1984	IDRC	Interamerican Inst. for Cooperation on Agriculture (IICA)	Univ. of Agriculture, Jamica
7	Improvement and Adaptation of Cassava Cropping Systems	Alantic Coast	March 1985	CIAT	CIAT	CIAT

Appendix I
Continued

Region & Project No.	Project Title	Location	Date Begin	Source of Funds	Contractor	Unit in Charge
Asia						
8	Lumle Agricultural Centre, Pokhara	Nepal	1968	British Gov't.	British Gov't.	Nepalese Government
9	Cropping Systems Research Program in Capiz Settlement	Philippines	1978	National Food and Agricultural Coun.	National Food and Agricultural Coun.	National Food and Agricultural Council
10	Farming Systems/Cropping System Res. for Upland & Rainfed Lowland	Indonesia	1981	Gov't. of Indonesia	Sukarami Res. Inst. for Food Crops, Indonesia (SARIF)	SARIF
11	On-Farm Verification of Improved Deep Vertisol Management Technology	India	1981	ICRISAT	-------	ICRISAT & Dept. of Agri. of States
12	Integrated Rainfed Farming Research and Development	Thailand	1981	UNDF/FAO	Farming Systems Res. Inst., Dept. of Ag., Thailand (FSRI)	FSRI, Thailand
13	Farming Systems Development Project, Eastern Visayas	Philippines	Sept. 1981	USAID	Cornell University	Ministry of Ag. & Food, Region VIII, Philippines
14	Cropping Systems Based on Rice	Vietnam	1982	Gov't. of Vietnam	Gov't. of Vietnam	Government of Vietnam
15	On-Farm Agronomy Project in Wheat-based Farming Systems	Pakistan	1982	USAID & Government of Pakistan	CIMMYT	Wheat Program, National Ag. Res. Centre, Islambad
16	Northeast Rainfed Agriculture Dev. Project (NECDP)	Thailand	FY1982	USAID	Univ. of Kentucky	University of Kentucky
17	Farming Systems Research and Development Project	Philippines (BICOL)	1983	USAID, Gov't. of Philippines	Winrock International	Ministry of Ag. & Food
18	IRRI/Burma Cooperative Res. in Rice Improvement, Rice-Farming Systems & Sm. Scale Mechanization	Burma	June 1983	Canadian Int'l Dev. Agency (CIDA)	IRRI	Ag. Institute and Ag. Corporation, Burma
19	Rainfed FSR	Thailand	Oct. 1983	USAID/FORD	USAID	Khon Kaen University
20	A Regional Analysis of Transfer & Performance of Rice-Based Farming Systems	Sri Lanka	Maha, 1983	Australian Center for Int'l. Agri. Research	Dept. of Ag. Sri Lanka	Dept. of Agriculture Sri Lanka
21	Northeast Crop Development Project (NECDP)	Thailand	1984	EEC	EEC	Farming Systems Research Inst., Dept. of Agri. Thailand
22	PARC/CIMMYT Maize and Wheat Program	Pakistan	1984	USAID	Pakistan Agri. Res. Coun. (PARC)	CIMMYT
23	Crop-Livestock Integrated Research, Proj. Khon Kaen	Thailand	April 1984	IDRC	Dept. of Agri. Thailand	FSRI, Thailand

Appendix I

Continued

Region & Project No.	Project Title	Location	Date Begin	Source of Funds	Contractor	Unit in Charge
Africa						
24	Highlands Programme	Ethiopia	1977	CGIAR	Int'l. Livestock Center for Africa	International Livestock Center for Africa
25	Pigeon Pea Project	Kenya	1977	IDRC/Kenya Gov't.	MESRES-IRA	MESRES-IRA
26	Niamey Dept. Development Project	Niger	1978	USAID	Development Alternatives Project	Ministry of Rural Development, Niger
27	Cameroon National Root Crop Improvement Program	Cameroon	Mid-1978	IRCC/Belgian Government	IITA	Institute of Agricultural Research (IRA) Cameroon
28	South Mali Farming Systems Research Project	Mali	April 1979	IDRC	----	Government of Mail
29	Groundnut Improvement Proj. of Univ. of Eduardo Mondlane & IDRC	Mozambique	Jan. 1980	IDRC	Univ. of Eduardo Mozambique	University of Eduardo Mondlane, Mozambique
30	Farming Systems Res. Proj.	Tanzania	1981	IDRC	Sokoine Univ. of Ag., Tanzania Gov't.	Sokoine, Univ. of Ag. Tanzania Government
31	Integrated Rural Dev. Proj. Basse Casmanee, Senegal	Senegal	1981	USAID	S.E. Consortium for Int'l. Dev. (SECID)	Louisiana University
32	Farming Systems Research for Communal Areas	Zimbabwe	1981	IDRC & Local Departments	Dept. of Research & Specialist Services Ministry of Ag.	Dept. of Research and Specialist Services - Ministry of Agriculture
33	National Cereals Research and Ext. (NCRE) Project	Cameroon	1981	USAID	Int'l. Institute of Tropical Ag. (IITA)	IRA
34	ICRISAT Sahelian Center ISC Economics Program	Niger	1982	CGIAR and Bilateral donors	ICRISAT, Sahelian Center, ISC	ISC
35	Zambian Ag. Research and Ext. Proj. (ZAMARE) Adaptive Res. Planning Team Component	Zambia	1982	USAID	Univ. of Illinois	Ministry of Ag. and Water Development Gov't. of Rep. of Zambia
36	Cropping Systems Research & Extension Project	Swaziland	March 1982	USAID	Penn State	Penn State
37	Project legumineuses alimentaires phase III, Burkino Fasso	Burkino Fasso	1983	IDRC	Gov't. of Burkino	Ministry of Ag. and Gov't of Burkino
38	Maximizing Use of Tilemsi Phosphate Rock	Mail	1983	IDRC/World Bank	IFDC(Int'l. Fert. Development Center)	Institute-Economic Rurale (Burkino-Mali)
39	Alley Farming Pilot Proj.	Nigeria	Oct. 1983	ILCA, IDRC, Ford Nigeria Livestock Project Unit (NLPU)	ILCA	NLPU
40	IRA-IITA-IDR On-Farming Research Project	Cameroon	March 1985	IDRC	Mesres-IRA	Mesres-IRA
41	[redacted]n Pr[redacted] Ag. Development Project	[redacted]a	[redacted]	IBR[redacted]D	--[redacted]	[redacted]tmen[redacted]gric[redacted]

Appendix II

DESIGN OF TRIALS IN FARMERS' FIELDS

FSR Survey

I. General Information

Project Title_____

_____

Region_____ Country_____

Time frame: Beginning date_____ Ending date_____

Funded by_____

Contractor_____

Contractor's Address_____

_____

Government agency or University in charge_____

_____

Name of person(s) completing form:_____

_____

Position in project:_____

_____

Local professional staff involved in project (including administration) - Note number.
BS:_____; MS_____: PhD_____: Non-degree_____.

Number in: plant science_____; animal science_____; social science_____; or engineering_____.

Of the above, how many are away on training:
BS _____; MS_____; PhD_____; Non-degree_____ Admn._____.

Expatriate professional staff involved in project (number)
BS _____; MS_____; PhD_____;

Number in: plant science_____; animal science_____; social science_____; or engineering.

Short-term consultancies, man months (in last year) - (number).
MS_____; PhD_____;

Number of field site locations (not individual farmer plots) where experiments are being conducted: _____.

Average number of professional staff (research workers) at each site_____.

Number of professional staff at headquarters (i.e. not working regularly at field sites).
_____.

Please define your target group in specific terms other than small, resource poor, subsistence, rainfed etc. (i.e. what is really meant by small or resource poor in your site?)_____
_____.

Are one or more of the following included in the target group:

(a) Households capable of producing most of what family eats: Yes____ No____
(b) Producers oriented toward the market: Yes____ No____
(c) Households who rely on wage labor: Yes____ No____
(d) Average farm size: (Define)_____
(e) Crops grown: (Define)_____
(f) Other (describe)_____
_____

How soon after the project's operational beginning were the first trials on farmers fields initiated (in months)_____?

Define the study region in geographic terms: (i.e., location, size, distance, between farthest experimental farm sites in kms)_____
_____

Have the sites where on-farm trials are located had (check if appropriate): baseline or benchmark surveys_____; follow-up surveys_____; surveys to assess impact_____; other (explain)_____
_____.

Have recommendation domains been identified in these areas: before field trials were established_____; during or after field trials_____; not at all_____; Other (explain)_____
_____.

What factors influenced the choice of field site locations?

	Strong	Moderate	Nil
Political	_____	_____	_____
Production potential	_____	_____	_____
Equity	_____	_____	_____
Type of crops grown	_____	_____	_____
Type of environment	_____	_____	_____
Proximity to research station	_____	_____	_____

Other (describe)_____
_____.

Who influenced the choice of initial trials and location of trials?

	Strong	Moderate	Nil
Those preparing project document	_____	_____	_____
National program administrators	_____	_____	_____
Research workers	_____	_____	_____
Extension workers	_____	_____	_____
Farmers	_____	_____	_____

Other (describe)_____
_____.

II. Identification of Type of Trial

In this section we ask you to define the type (types) of trial that you are using in your research. There are at least three types of trials commonly employed in FSR. The different types are distinguishable on the basis of four categories of terms. The categories are: 1) characteristic; 2) description (based on Hildebrand) 3) objective (based on Gomez and Gomez); 4) management. The terms that you check below under the four category designations (see definitions of terms at the end of the survey) will determine how many types of trials your project employs. Let us give an example with reference to our Philippine project. We have conducted two types of trials in farmers' fields. Type I was varietal testing, site specific, technology generation, and researcher managed. Type II (still going on) is cropping pattern, regional, technology verification, and farmer-researcher managed.

If you feel that more then three types of trials are employed by your project feel free to duplicate Sections II, III & IV and fill them out for the additional types.

Trial Types

1. Characteristic of Trial (check one per column)

	Type 1	Type 2	Type 3
Cropping patterns	_____	_____	_____
Intercropping	_____	_____	_____
Multi-story (crops under tree crops)	_____	_____	_____
Alley farming (crops between hedge rows)	_____	_____	_____
Varietal testing	_____	_____	_____
Pasture establishment	_____	_____	_____
Soil fertility	_____	_____	_____

Other component technology testing (explain)_____

_____

_____

Some combination of above (describe)_____

_____.

Other (describe)_____

_____

2. Description of trial (check one per column).

Exploratory	_____	_____	_____
Site specific	_____	_____	_____
Regional	_____	_____	_____
Extension	_____	_____	_____

Other(describe)_____

_____

3. Objective of trial (check where appropriate)

	Type I	Type II	Type III
Technology generation	_____	_____	_____
Technology verification	_____	_____	_____
Direct adoption of technology by farmers.	_____	_____	_____
Adoption of new technology	_____	_____	_____
Feed back information to experiment station on research needs for component technology.	_____	_____	_____

Other (describe)_____

_____

4. Management of trial (check one per column)

Researcher managed, researcher implemented	_____	_____	_____
Farmer-researcher managed, farmer implemented	_____	_____	_____
Farmer managed, farmer implemented	_____	_____	_____

Other (describe)_____

_____

Do farmer-researcher managed trials have: (check one)

(a) nominal farmer participation_____;

(b) consultative participation where researchers actively consult with farmers and farmers implement management operations_____;

(c) decision-making participation in which farmers are involved in the design of trials_____.

Frequently in FSR projects there is a sequence in types of trials being done (e.g., Type I which is exploratory and researcher managed is done first etc.) In other cases different types of trials are done simultaneously. In your project different trial types (check one)

Are strongly sequential_____

Are moderately sequential with some overlap and interaction - _____

Are done simultaneously_____

Not relevant, only one trial type_____

III. Technical details of trials

TYPE I (from previous section)

Range in number of treatments_____; Range in number of reps on farm_____;
Range in number of reps across farm_____; Range in size of plots_____;
Treatments are (check 1) superimposed_____; not superimposed_____; both____.

Who/what influenced choice of treatments (check where appropriate)?

	Strong	Moderate	Nil
Those preparing project document	_____	_____	_____
National program recommendations	_____	_____	_____
Experiment station results	_____	_____	_____

Researchers - ag. sciences	_____	_____	_____
Researchers - social sciences	_____	_____	_____
Extension agents	_____	_____	_____
Farmers	_____	_____	_____

Other (describe)_____
_____.

Is there a control: Yes_____; No_____.
Is the control standard across farms: Yes_____; No_____;
Describe control_____
_____.

TYPE II (from previous section)

Range in number of treatments_____; Range in number of reps on farm_____;
Range in number of reps across farm_____; Range in size of plots_____;
Treatments are (check 1) superimposed_____; not superimposed_____; both_____.

Who/what influenced choice of treatments (check where appropriate)?

	Strong	Moderate	Nil
Those preparing project document	_____	_____	_____
National program recommendations	_____	_____	_____
Experiment station results	_____	_____	_____
Researchers - ag. sciences	_____	_____	_____
Researchers - social sciences	_____	_____	_____
Extension agents	_____	_____	_____
Farmers	_____	_____	_____

Other(describe)_____
_____.

Is there a control: Yes_____; No_____.
Is the control standard across farms: Yes_____; No_____.
Describe control_____
_____.

TYPE III (from previous section)

Average number of reps across farm_____; Average size of plots_____;

Treatments are (check 1) superimposed_____; not superimposed_____; both_____.

Who/what influenced choice of treatment (check where appropriate)?

	Strong	Moderate	Nil
Those preparing project document	_____	_____	_____
National program recommendations	_____	_____	_____
Experiment station results	_____	_____	_____
Researchers - ag. sciences	_____	_____	_____
Researchers - social sciences	_____	_____	_____
Extension agents	_____	_____	_____
Farmers	_____	_____	_____

Other(describe)_____
_____.

Is there a control: Yes_____; No_____;
Is the control standard across farms: Yes_____; No_____;
Describe the control_____
_____.

IV. Farmer and Researcher Involvement in Trials

How were farmers chosen to cooperate in field trials (check one):

Type I

Random sample:_____
Purposeful sample:_____
Selection of farmers willing to cooperate_____
Selection of "best" farmers_____
Other (describe)_____
_____

Are co-operating farmers in the target group (see page 2); (check one)
all_____; some_____; none_____.

If some or all the farmers are not listed in the target group explain why:
_____
_____
_____
_____

Type II

How were farmers chosen to cooperate in field trials (check one).
Random sample:_____
Purposeful sample:_____
Selection of farmers willing to cooperate_____
Selection of "best" farmers_____
Other (describe)_____

Are co-operating farmers in the target group (see page 2); (check one):
all_____; some_____; none_____;

If some or all the farmers are not in the target group explain why:_____

Type III

How were farmers chosen to cooperate in field trials (check one):

Random sample:_____
Purposeful sample:_____
Selection of farmers willing to cooperate_____
Selection of "best" farmers_____
Other (describe)_____

Are co-operating farmers in the target group (see page 2); (check one):
all_____; some_____; none_____.

If some or all the farmers are not in the target group explain why:_____

How are farmers involved in trial (check 1 in each line)

	Strong	Moderate	Nil
Type I trial -			
Involved in decisions on treatment	_____	_____	_____
Involved in decisions throughout crop season	_____	_____	_____
Involved in evaluation of trials	_____	_____	_____
Involved in extension of results	_____	_____	_____
Type II trial			
Involved in decisions on treatments	_____	_____	_____
Involved in decisions throughout crop season	_____	_____	_____
Involved in evaluation of trials	_____	_____	_____
Involved in extension of results.	_____	_____	_____
Type III trial -			
Involved in decisions on treatments	_____	_____	_____
Involved in decisions throughout crop season	_____	_____	_____
Involved in evaluation of trials	_____	_____	_____
Involved in extension of results	_____	_____	_____

How is the research team involved in the field trials (check if appropriate).

Type I

Provides seed and other inputs for treatments only:_____
Perform, or hire labor for operations:_____
Makes management decisions on: (check appropriate answers)
planting date_____; weeding times_____; application of treatments_____;
when to harvest;_____.
Rents land from farmers:_____
Compensate farmers for crop loss:_____
Other(discuss)_____

Type II

Provides seed and other inputs for treatments only:_____
Perform or hire labor for operations:_____
Makes management decisions on: (check appropriate answers)
planting date_____; weeding times_____; application of treatments_____;
when to harvest_____.
Rents land from farmers:_____
Has agreement to compensate farmers for crop loss:_____
Other (discuss)_____

Type III

Provides seed and other inputs for treatments only:_____
Perform, or hire labor for operations:_____
Makes management decisions on: (check appropriate answers)
planting date_____; weeding times_____; application of treatments_____;
when to harvest_____.

Rents land from farmers:_____
Has agreement to compensate farmers for crop loss:_____
Other (discuss)_____

V. General Questions and Comments

Many times what we start out to do in field trials changes dramatically for one reason one another. Have there been any major changes in your field trial procedures? (Explain)_____

Did you confront problems in:

Obtaining seeds for trial:(explain)_____

Getting trials planted in time: (explain)_____

Germination of seeds: (explain)_____

Obtaining appropriate data on crop production: (explain) _____

Attaining accurate harvest yields:_____

Conducting agronomic analysis of trials: (explain) _____

Conducting economic analysis of trials: (explain)_____

Others: (explain)_____

In your farm experimental program, what were its most successful/useful points that you think might help other people in conducting on-farm experiments?

_____.

In your experimental program, what were the most serious problems which you would advise others conducting on-farm experiments to try and avoid?

_____.

Thank you again for your time and help.

Please mail the completed survey to:

Dr. Randolph Barker
Dept. of Ag. Economics
349 Warren Hall
Cornell University
Ithaca, N.Y. 14853

Appendix IIb

DEFINITION OF TERMS FOR FIELD TRIAL TYPES

Characteristic of trial

Cropping pattern - crops grown sequentially in a rotation.

Intercropping - two crops grown in the same field simultaneously.

Multi-story - crops grown under tree crops.

Alley cropping - crops grown between rows of tree crops designed to control erosion.

Varietal testing - varieties as the major treatments.

Other component technology testing - e.g. fertilizer, insecticide, weed control etc.

Description of trial

Exploratory - used when little is known about an area; usually complementary to domain characterization and typically researcher managed, preceding site-specific and regional trials.

Site-specific - to obtain basic agronomic information and or measure the deviation from the potential for a specific site. Typically researcher managed with only minimal farmer participation. Similar in design to on-station trials but with fewer treatments.

Regional - to define the interaction of the technology with the environmental conditions from an agronomic and a socio-economic viewpoint. Treatments may be selected from previous site-specific trials and may include. among others, the farmers own technology as a control. Typically researcher-farmer managed with farmers having a full knowledge of the variables studied and anticipated results.

Extension - to test and evaluate one or two of the most promising treatments from the regional trials usually with a large number of farmer managed trials.

Objective of trial

Technology generation - For on-farm experiments in technology generation the farms become an extension of the research station, with each farm representing a specific combination of environmental factors. Consequently it is primarily the physical and biological environment of the farm that is incorporated into the evaluation process. The experiments are designed and managed in a manner similar to those conducted in a research station.

Technology verification - Experiments for technology verification are designed to verify the superiority of newly developed technology over the farmers existing practice in his own farm environment. Experiments are typically conducted on a fairly large number of farms to compare the new technology with the farmers practice.

Management of trial

Researcher managed and implemented - The trial is layed out and treatments applied under direct supervision of the research team.

Researcher-farmer managed and implemented - There is a dialogue between researchers and farmers in determining treatments to be included in the experiments, size of plot and factors involved in the management of the trials. Researchers normally manage the trials.

Farmer-managed and implemented - The researchers may or maynot provide the farmers with inputs needed to conduct the trials, but farmers manage the trials.

ON-FARM RESEARCH: SOME ALTERNATIVE APPROACHES

by

David Gibbon

INTRODUCTION

Over the past ten years interest has grown considerably in on-farm research activities within agricultural research programs. It is now generally accepted that this has come about as a result of the serious and thorough reassessment of older agricultural research methods, which, when applied to the problems of resource poor farmers inhabiting a wide range of agro ecological environments, were found to be deficient in many ways. Perhaps it is important to note here that most of the important, constructive criticism of formal, station-based, mono crop, mono-disciplinary, high input/output research came from social scientists, particularly agricultural economists. Many natural scientists have been slow to accept some of this criticism and even slower to contribute actively, both to the debate about alternatives and to evolve new methods and approaches to resource, crop, and livestock experimentation within the context of real life situations and integrated on-farm and on-station programs.

In many research programs and projects, on-farm research has now become a major and even dominant component and the main avenue for the development and exemplification of the farming systems research/extension (FSR/E) approach.

These developments have been quite remarkable and yet there are widely differing views on the role that on-farm research should play in FSR/E. While much of the earlier work has focussed on the collection of data and its use in identifying client groups there still is no agreed methodology for conducting experimental research on farms and little informed writing on how this work relates to other types of experimental procedures. Also we still have few, longer term, assessments of the relative merits of different approaches to on-farm research.[1] In addition, few attempts have been made to determine the effectiveness of on-farm projects.[2]

This paper attempts to highlight the main characteristics of some current on-farm research approaches and methods, in the context of their contribution to overall research and national

1 / In the agricultural research planning and management course at the University of East Anglia we review different on-farm research programs (Biggs, 1985: Gibbon, 1985). Chambers and Ghildyal (1984) also discuss alternatives.

2 / At a recent workshop Biggs and Gibbon (1985) and Clay and Clark (1985) identified and discussed criteria for assessing the effectiveness of on-farm research programs and Anderson (1982) notes the lack of serious analysis justifying on-farm research.

government objectives, and in relation to their ability to respond to identified needs and to solve problems of farmer clients. It will also consider longer term, environmental issues that are frequently neglected in the continuing enthusiastic drive for simple solutions to what are usually complex problems. Finally, it will address another area of growing concern which is the serious gap in understanding, by the participants in on-farm research, (scientists, extension agents and farmers) of objectives of field trials and what can realistically be expected of them in the short and longer term. (Rhoades, 1984).

During recent years there have been a series of valuable reviews of on-farm and FSR/E that have contributed greatly towards the development of methods and procedures for identifying research priorities and for setting out alternative frameworks for FSR/E programs (Chambers and Ghildyal, 1984; Gilbert et al, 1980; Biggs, 1982; Fresco, 1984; Shaner et al;, 1982). We now also have a growing library of excellent empirical case studies of FSR/E projects carried out in a range of environments. However, much of this reported work does not extend beyond the first 3 to 4 years of the project and therefore on-farm experimental work is frequently at an early stage (Biggs, 1983; Cornick and Kirkby, 1981; Collinson, 1982; Zandstra, 1979).

Some of the work that is regarded as FSR/E is, in fact, crop improvement and cropping systems research which may often form a dominant part of the FSR/E program. Perhaps the best known, and certainly the most influential, has been the ten years of rice-based cropping systems research guided by the International Rice Research Institute (IRRI) in Asia (Hoque, 1984; Morris, 1984). While this work has undoubtedly broadened in scope since its inception, much on-farm research elsewhere is still primarily based on an annual food crop, single livestock types, or narrow, technical problem solving (Choudhry et al., 1982; Tollervey et al., 1980; Hussain and Sikder, 1983; Brannon et al., 1979; Martawijaya, 1981; Agrawal, 1983).

Emerging from the major writings is a broad consensus of agreement on the key elements of on-farm and FSR/E. These are: client-orientated, usually small or poor farmers, holistically focussed on farmer environments, concentrated on food production and security, interdisciplinary, problem-solving, dynamic, and able to provide continuing linkages from farmers to policy makers and planners. Clearly, rather different emphases have emerged from the very different farming systems programs and projects that exist; from those originating from national or regional programs, special aid projects, or from the International Agricultural Research Centres (IARCs). There is certainly a

variable interest in the degree of training and participation of local scientists and farmers in many internationally funded projects and also in the concern for longer term stability of farming systems above short term yield improvement concerns.

There are also important structural and managerial differences in the place and importance that FSR/E is granted within different research systems (TAC Review, 1978; Simmonds, 1985). These differences give rise to very different resource allocations to FSR/E and whether on-farm research activities can have a significant bearing on the effectiveness of the overall research program.

Another area of potential misunderstanding is in the varying ways in which FSR/E programs are structured and organised. A number of influential writers have established a common structure for FSR/E which involves a four (or five) stage process, description and analysis, design, testing, and extension (Collinson, 1982; Norman, 1980; Gilbert, Norman and Winch, 1980; Baker et al., 1983). Though most of the writers who have developed these ideas stress the importance of considering the whole development of new or alternative technologies as a continuing, iterative process, this basic framework is continually being refered to and used as a top-down, four step process that closely resembles some of the older simplistic models that it was meant to replace. One of the reasons for this is that many programs have rarely moved beyond the collection of data, identification of priorities, and early field experimentation activities that are really only the beginning of serious long term research programs. The earlier work has rightly focussed on the development of an understanding of existing systems and we now seem to be moving to a period of intense concentration on "stage 2" the design and development of alternative technologies with a strong emphasis on on-farm experimentation and farmer-controlled experimentation.

These trends are unfortunate for the reasons indicated earlier as they frequently lead to unbalanced programs. In the following discussion an attempt will be made to examine the effectiveness of on-farm research within a FSR/E program by using an evaluative criteria checklist developed elsewhere (Biggs and Gibbon, 1984). This will both examine present practice and point out areas of major weakness or gaps.

National Objectives

Most on-farm and programs must relate in some way to national economic priorities, whether it be to produce surplus food or

fibre for urban populations, industry or export or to provide stability of livelihoods for rural populations. This means that research priorities must include attempts to improve productivity of systems but not at the expense of destabilising them or of making some groups even poorer. Employment generation may also be of high priority but there is little evidence that this issue has been taken seriously in most FSR/E programs.

Sources of Local Knowledge

Most writers now agree that effective on-farm research can only occur following the development of a thorough understanding by researchers and extensionists, of the climatic, biological, social, institutional, and economic environment of farmer clients (Horton, 1983; Doherty, 1982; Winkelman and Mosardi, 1979; Kirkby et al., 1981; Sanders and Lynam, 1982; Biggs, 1982; Rhoades and Booth, 1982; Rhoades, 1982; Baker et al, 1982; Benoit-Cattin, 1980). Many would argue that an essential part of this would be the active and continuing participation of farmers in this learning and exchange process because it is only farmers who have the intimate and experienced knowledge of their own environments and their contribution to the future development of alternative is vital (Chambers, 1983; Chambers and Ghildyal, 1984; Richards, 1985; IDRC, 1984; IDS, 1979; Brokensha, 1980). While knowledge is certainly important in many environments, there are areas, particularly those that have suffered recent drastic reductions in rainfall where the basic fund of relevant indigenous knowledge might be very limited and greater reliance on newly collected and created data is essential.

Two other points are also important: first there has been a persistent tendency to collect excessive amounts of data, much of which may have only marginal relevance to local development problems (eg. the problem of the large benchmark survey). Secondly, a number of projects have frequently regarded initial data collection, both quantitative and qualitative, as a "one-off" operation. More important in many ways is the need to develop methods of studying change over time and the ability of the program to respond quickly to information gathered. A knowledge of how changes in technology occur within the existing system will be an invaluable guide to developing and introducing viable alternatives (Gibbon, 1981).

Client Groups

Most FSR/E work suggests that agricultural research should focus primarily on resource poor groups (Chambers, 1983; Biggs and Gibbon, 1984; Norman, 1980). This proposition is based on the grounds that the benefits of previous research usually accrued to wealthier farmers who made up a minority of farmers. Poorer groups were often ignored or unaffected by the output from formal research. While the need to work with the majority or poorer groups is vital, some research information collected on-farms, such as micro-environmental characterisitics, and basic relationships between climate, vegetation, soils, and livestock, is essentially neutral and could have general value, particularly in planning longer term resource use.

Many natural scientists still do not accept that the focus on resource poor producers should affect either what their priorities should be or how they should carry out their research. Much research still involves the examination of alternatives using inputs that are either unobtainable or not available in the quantities used in trials. Many scientists consider that it is the responsibility of governments to provide the necessary inputs at the right time and place.

The further specification of farmer-clients and 'domains' continues to be a subject of much research interest (Franzel, 1983; Byerlee and Collinson, 1980; Harrington, 1980; Hildebrand, 1984). As yet there is still little evidence that the more detailed specification of farmers and their situations are essential prerequisities for the development of alternative or optional technologies for specific groups of poor clients. Moreover, there is a danger that excessive refinement could result in increasingly narrowly applicable technologies,and a growing gap between research station scientists and on-farm groups.

Monitoring, evaluation and replanning

As was stated earlier, many programs are reported in their initial stages of development and it is hard to find examples of programs that have evolved and changed direction through the results of, regular/review, evaluation and replanning procedures. Where this has been the case, the value of these procedures has been very significant (Agrawal and Saxena, 1985; Biggs, 1982 & 1984; Martinez, 1984; Zandstra, 1979). We need more analysis

on why some programs respond to feed back and others do not.

Interdisciplinary Analysis

Interdisciplinary analysis is considered to be essential for effective on-farm research and there are a small, but growing number of examples of constructive interaction between social and natural scientists (Rhoades and Booth, 1982; Horton, 1984; Kiene, 1981). Much of the initiative for this approach still comes from social scientists and while mixed teams of natural scientists are becomming the norm, the presence of social scientists (not only agricultural economists) as fully integrated members of research teams is still quite rare. There is plenty of rhetoric on interdisciplinary analysis and little in reality. It is particularly important that mixed teams decide research priorities and work on solutions together and do not develop their own disciplinary sectors of research programs in isolation (Gibbon, 1985).

Integration of on-farm and on-station research

The recent emphasis on on-farm research trials and methods has sometimes led to the separation of activities from research at main and sub-stations. This has sometimes led to considerable confusion among many junior and middle level scientists in national programs as the objectives and goals of research become confused. Much research experimental work takes place in an interacting series of locations and levels. It is as inappropriate for all research trials to take place on farm lands, with or without the participation and control of farmers, as it would be if all field trials were conducted on main experimental stations (Martin and Gibbon, 1980). A structured, linked set of trials is desirable for effective on-farm research.

The use of the farming systems research extension approach

It follows from the foregoing discussion that any on-farm research must be carried out within the context of the existing farming and rural life system if it is to evolve technologies that can be used by many resource poor farmers.

The methods used for on-farm research range from the preliminary investigation and analysis of climatic, environmental, biological, crop, livestock, and economic resources, to field trials, evaluation, and multilocation testing and verification. It is clear that many older approaches and methods are still used even in programs that purport to be FSR/E oriented. Crop production trials predominate and the major objective and measure of "success" remains increases in output per unit area or per animal unit and the simple cost/benefit analysis of technologies involving increasing inputs (Choudhry et al., 1982; Erskine, 1983).

The so-called "constraints analysis" and investigation of the

"yield gap" between station and on-farm results is still the preoccupation of some workers (Sanders and Lynam, 1982; Brannon et al., 1979; Martawijaya, 1981).

There are relatively few papers on methods of collecting appropriate environmental data (Whiteman, 1985; Krantz, 1981). Trial design and methods are very dependent upon classical experimental principles and may be rather inflexible and sometimes over prescriptive (Sevilla, 1980; Zandstra, 1981; Perrin et al., 1978; Morris, 1984).

A very large number of on-farm trials involve manufactured chemicals, fertilizers, herbicides, fungicides, herbage or bi-product additives, and consist of simple comparisons of alternative treatments (Hildebrand, 1984; Saxena and Stewart, 1983; Erskine, 1983; Agarwal and Verma, 1983; CIAT, 1981; Tollervey, 1980; Jennings and Drennan, 1979). Only a few of these trials could be said to involve a FSR/E approach as most were apparently carried out in isolation without consideration of their interaction with other aspects of the system.

There is another important issue here. There seems to be the tacit assumption that developing country farming systems will take on all the so-called modern chemical inputs that have been a significant feature of Western agricultural systems over the past 40 years. The rationale for this is always that short-term yield increases are paramount and therefore anything that will increase the yield of economically useful crop or livestock products in the short term is justified. We are approaching a growing crises in Western production systems as we over produce foods, create pollution, and soil degredation at increasing rates and put chemical residues into foods. It is surprising that the principles of the excellent recent studies on biological or organic systems in the US and Europe (Edens et al., 1985) are not used more fully in planning farming systems work in the tropics. Fortunately, in this sense, as farmers in most developing countries have only poor access to modern chemicals, there would appear to be great scope for focussing more seriously on technologies that are more appropriate to their circumstances and that will provide stable and safe food supplies for the future. In these areas the work on intercropping (ICRISAT 1979), alley cropping (IITA, 1982), multiple cropping (Blackie et al, 1980), better utilisation of animal draft (Gryseels, 1983), soil and water management (ICRISAT, 1983), food storage research (Potts et al, 1983; Horton, 1983), and lower-yielding early maturing varieties (Knipscheer, 1980) are just a few examples of research that may be of greater long term value.

Another concern in this context is the continuing deterioration of soil and water resources brought about by a combination of natural changes and the activities of resource users. Longer term soil fertility maintenance and water resource conservation issues are rarely addressed in agricultural research programs (the

work of ICRISAT (Krantz, 1980) on alley cropping is exceptional) but it is vital as many of the technologies currently recommended, if applied generally, will do nothing to alleviate the problem.

Integration with other scientific research programs

It follows from the last point that on-farm research cannot hope to solve all the problems of resource use in rural areas. It can only be regarded as one system or means of influencing change in the rural environment. It is for this reason that it is so difficult to assess the effectiveness of research as change at farm level alone will occur due to a range of reasons. On-farm research can be made more effective through linkages and joint action with other programs, soil and water conservation, forestry, community projects, integrated rural development programs etc. This can occur through regular formal and informal communication and through joint participation in work programs.

Integration with extension systems

Many countries have inherited research and extension systems that are located in different ministries or parts of ministries of agriculture and many have different sources of funding, mandates, and responsibilities. This is most unfortunate as on-farm research is the ideal situation for the productive integration of research, extension, and farmer activity and alternative technologies cannot be widely successful without strong linkages between all three. Too many research programs are isolated from extension activities and too few extension workers are directly involved in the development of new technologies. Some programs have overcome these problems by creating liaison units or joint adaptive research teams (Kean, 1982; IITA, 1982) but elsewhere the continuing gulf between research and extension is seen as a major problem (OECD, 1981; Fitzherbert, 1980). The problem often stems from the perception by experimental station researchers that the major role of extensionists is to carry the results of research from 'lab to land'. The other, as important, role of extension: namely to help redirect and control the priorities of research station work, is often no more than a feedback arrow on a diagram.

Local research capability

The impression still remains, from literature and from personal observation, that the current wave of on-farm research and experimentation is largely inspired and heavily directed from outside national programs.. While it is accepted that some techniques are new, the use of massive external resources, training programs in inappropriate locations and environments, and the tendency to adopt excessively detailed methodology packages, will all tend to stifle, not stimulate, local initiative in developing indigenous approaches to on-farm problem solving and training methods. Ultimately local scientific

research and extension staff must have full control and responsibility for their own programs and be able to work within local research resource constraints.

Farmers must also continue to have options on the make- up of their own technology mixes. It is perhaps sometimes forgotten that there may be more than one way of achieving the same benefit or satisfaction. Most of the work carried out over the last 20 years on technology packages indicates that the more elaborate the package is, (for example, the ICRISAT watershed package (Krantz, 1980) the less likely is it that it will be adopted widely. Farmers tend to select those parts of the technology that are best suited to their circumstances at a particular time (Brammer, 1980; Ryan and Subrahmanyam, 1975; Mann, 1978). Despite this, many on-farm programs continue to refine a relatively narrow range of technology options or production packages.

Informal research

Far too little emphasis and acknowledgement is given to the role of informal research by farmers and others. Most farmers are constantly experimenting with the alternative use of resources and new techniques. It would seem to be vital that the results of this work are built into the regular analysis and evaluation of on-farm research programs.

Institutional reward systems

Despite the literary popularity of on-farm research, there is still inadequate recognition in many national research systems of the importance of this work, either academically of financially. It is difficult to carry out and as senior, experienced researchers are still reluctant to spend anything more than a short time in field environments, it is often carried out by young, often inadequately briefed, scientists. It is perhaps early to make a judgement on these matters, but if senior scientists are convinced of the value of this work then adequate rewards should be provided. Clearly, there is also a need for a major overhaul of training programs at all levels if these difficulties are to be removed in the long run.

Alternative Approaches

It is accepted that there are a number of very effective research and extension teams carrying out excellent on-farm research with a FSR/E perspective. There are also many on-farm programs that have been badly implemented,many of little value, and some that may have been harmful, creating more problems than they have solved.

In the foregoing discussion we have looked at agricultural research objectives and goals, the actors in research and extension systems, the range of locations for research, research

activities and methods, and the expected outputs from on-farm and FSR/E. An attempt will now be made to draw from these experiences to emphasise some key elements and their interactions for effective on-farm research.

Perspectives of Farming Systems Research/Extension

It would seem that we need a broader concept of the potential role of on-farm research, and of agricultural research more generally, in helping to solve changing resource problems and the problems of poor rural people. "On-farm" sould surely refer to any activity that involves the study, experimentation with and development of farmer/cultivator clients in their specific environment or common renewable resources that are used for food or other agricultural products or household needs. This means that the deeper understanding of rural life systems is not only a prerequisite but also a continuing need within on-farm research programs.

On-farm Research as a Component in a System

While on-farm research must continue to play a pivotal role in agricultural research programs, it must also be seen as one component of a series of interacting activities that take place at different locations (laboratory, main experimental station, researcher-managed sub-site, and even international research test sites). This means that FSR/E practitioners will need more understanding of how to interest and influence other parts of the system.

Interaction and Linkages

Only through the continuous interaction of scientists with on-farm research activities (both formal and informal) in a range of agro ecological and socio economic environments can they hope to understand how systems change and evolve over time and therefore how alternative technologies may be successfully introduced.

Capitalise on Informal Research and Development

There is scope for the use of a greater range of experimental methods in on-farm research and the acknowledgement that different types of information, such as the environmental characteristics of Whiteman (1985) which identify limitations and also opportunities, and the use of qualitative information, informal trials and farmer experimentation (Biggs, 1981; ICARDA, 1980; Richards, 1985) are all equally valuable in the overall research effort.

Clients of Research

There are clear differences of opinion on the extent to which on-farm research should lead to the narrow prescription of an alternative technology for a specific group of farmers or whether

researchers should be presenting a broader range of options for all farmers. There is no doubt that by building new technologies around higher inputs (particularly imported chemicals and machinery) and persistantly using yield per unit area as a measure of output (success) scientists are making a choice and value judgement about the future socio economic conditions of agricultural systems and the types of clients they wish to serve. Equally, scientists who focus on lower input systems, labor generation or intercropping are also directing their work towards resource poor farm environments.

Farmers as Part of Social Structures

Much on-farm experimentation still focusses on individual farm systems and fails to take account of important societal interdependence (with regard to the sharing of labor and resources, for instance). Also the differences between developing new technologies for share croppers, or people who have a significant proportion of their income from non-agricultural sources or for farmer/owner-occupiers are usually avoided.

Research is Part of the Overall Political Economy

Finally, we must address the overriding problems of objectives, values and goals. Clearly, the continuing provision of adequate supplies of high quality foods for rural and urban based people in developing countries is of paramount importance. The question is, how can that requirement be adequately satisfied equitably without excessively increasing dependence on increasingly scarce inputs, contaminating foods or degrading the environment further? The question obviously involves the policies and plans of governments and the inter relationships between nations but it also cannot be avoided by those who are responsible for developing and propagating new or alternative methods of resource use. The question has important long run implications that relate to the stability of systems that are rarely considered in current on-farm research programmes, and demands that we rethink some of our priorities in research. As mentioned earlier, the current America/European debate on sustainable or regenerative agricultural systems (Dahlberg, 1985) is very relevant here.

It would seem crucial that we plan and conduct on-farm research, particularly field trials, with a much greater care than we are presently doing. We ought to be doing much more work that has longer term implications, such as those related to fertility maintenance, conservation, and the maintenance of flexibility and stability of systems. We need to question, wherever appropriate, the introduction of chemical inputs and certain types of machinery and always look for alternative methods of pest and disease control and soil and water management. Many of these methods did exist, less than 30 years ago, and still do in some areas. Above all we should avoid repeating the mistakes of past attempts to modernise agriculture by working with our farmer clients at all stages of research and extension programs.

Conclusions

1. On-farm research is important. Senior scientists and extension staff have to be involved as it is only their skills, experience and contacts which are able to interpret and use research for influencing experimental station research and extension recommendations.

2. The scope of on-farm research must be increased - at the cost of less station-based research if necessary.

3. Linkages between station and on-farm research and extension must be strengthened otherwise we will have created yet another set of jobs which will have relatively little impact on achieving long term goals and potential.

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ON-FARM TRIAL CASE STUDIES

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Technology Evaluation, Policy Change and Farmer Adoption in Burkina Faso

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Introduction

Purdue University began farming systems research in Burkina Faso in 1979 under the Semi-Arid Food Grain Research and Development project (SAFGRAD), a regional research coordinating program with major funding from the United States Agency for International Development (USAID). Among various research themes, the farming systems unit (FSU) stressed water conservation and soil fertility. This paper presents FSU's field trial and socioeconomic program related to water conservation (tied ridges) and soil fertility (fertilization). The paper starts with background on Burkina Faso. Diagnostic and farming systems information are then presented leading to the description of the on-farm farmer-managed trials and the socioeconomic program and presentation of the results. The evaluation of the technology interventions are then presented followed by the modifications that were made to the research program from the information gained in the preceding field campaign. Linear programming is used to analyze the technology interventions in a whole farm context.

Background on Burkina Faso[2]

Burkina is situated in the zone known as the semi-arid tropics and the climate is Sudanian with the exception of the northeast which is Sahelian.[3] There are three distinct seasons: warm and dry from November to March, hot and dry during March through May and hot and wet from June to October. Daytime temperatures during the cooler November to March period average about 30°C and drop to 16°C at night with very low humidity. The temperature starts to climb in March and by May most daytime temperatures reach into the 40°C range. During the rainy agricultural season, daytime temperatures range between 27°C and 32°C. Once the rain stops in the fall, temperatures again begin to climb to the 40°C range during October until cooler weather sets in about mid-November. Long term average annual rainfall ranges from 500 mm in the northeastern Sahelian zone to 1400 mm in the extreme southwest. Isohytes

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[1]The authors would like to thank John Sanders, Agricultural Economics Department, Purdue University and Lee Schaber, Peace Corps Volunteer, for their assistance.

[2]Burkina Faso was formerly Upper Volta. The background information on Burkina is a synthesis of several publications: World Bank, 1982; Jaeger, 1982; United States Department of State, 1984.

[3]Burkina is a landlocked country in the center of West Africa bordered by Mali on the north and west, Ivory Coast, Ghana and Togo on the south and Benin and Niger on the east (Fig. 1). The country is located between 9°20′ and 15°5′ latitude north and 2°20′ longitude east and 5°30′ longitude west of the prime meridian. The land area of the country is 274,000 km^2 of which an estimated one-half is arable. Eighty-five percent of the area is plains with an altitude of between 200 to 300 m above sea level.

tend to be horizontal except for the southwest where rainfall is heavier than in the southeast. Since the mid-sixties, annual rainfall has averaged 100 to 150 mm below the long term average within each of the isohyets.

The population of Burkina is estimated at 7.2 million (1983) with an annual growth rate of 2.6%. Most of the population lives on a plateau in the central part of the country referred to as the Mossi or Central Plateau. Population density is very high in this area approaching 48 per km^2 in some locations as compared to 12 per km^2 in the north and east. Burkina is the largest supplier of emmigrant workers in West Africa. It is estimated that 25% of its work force, mainly better educated young single men, work in the Ivory Coast, Ghana, Mali and Senegal. This results in an annual net population growth rate of 1.7%. About 90% of the population live in rural areas with 83% of the labor force engaged in agriculture. The literacy rate is 5%.

Food security continues to be an important problem for Burkina. Although increases in food availability (including imports) have kept pace with population growth allowing per capita consumption to remain constant, aggregate caloric intake is 85% and lipid consumption 50% of nutritionally recommended levels (Haggblade, 1984). The World Bank's average index of food production per capita dropped six percentage points between 1971 and 1981. Assuming the current increase in population growth, total food production will have to increase by 30% by 1990 to maintain the current consumption levels without greater reliance on imports (Singh, 1984).

Diagnostic and Farming Systems Information

The major objectives of the farming system unit (FSU) were to identify the principal constraints to increased food production and to identify technologies appropriate for farmers which can overcome the production constraints (Ohm et. al., 1985a). To achieve the objectives, FSU conducted on-farm researcher-managed and farmer-managed trials and collected base line and socioeconomic data in up to five villages.[4] Villages were selected to represent different agroclimatic zones with different agricultural potential, differences in access to land, and represent, as far as possible, a complete range of tillage practices. The village of Bangasse has very few animal traction farmers whereas about one-half the farmers in Nedogo use donkey traction. The Dissankuy and Diapangou sites have a complete range of manual, donkey, and ox traction farmers. Dissankuy, which is just off the Mossi Plateau has the greatest agricultural potential followed by Diapangou, Nedogo, and Bangasse all of which are on the Mossi Plateau. There is limited access to land in Nedogo and Bangasse.

Planting of crops begins with the first significant rains, some time between early May and late June. Labor constraints are most pressing at planting and at first weeding. Labor is less constraining during second weeding and the period that follows. The major staple crops grown are millet, white sorghum, and maize. Small quantities of rice are grown in the bottom lands. In Nedogo, a red sorghum is grown for the making of local beer. Cash

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[4]The four villages of concern for this paper are: Nedogo--30 km northwest of Ouagadougou, Bangasse--110 km northeast of Ouagadougou and 15 km from the major center of Kaya, Diapangou--210 km east of Ouagadougou and 15 km from the major center of Fada-nGourma and Dissankuy--120 km north of Bobo-Dialasso (Fig. 1). The ethnic group in Diapangou is Gourmantche, a mixture of Dioula and Mossi in Dissankuy and predominantly Mossi in the other villages.

crops include peanuts, bambara nuts, and cowpeas. Cowpeas are usually intercropped with sorghum and millet. Other crops include okra, peppers and sesame. Cotton is a major crop in Dissankuy (FSU/SAFGRAD, 1983).

The soils are classified as alfisols and are red to reddish brown in color. Soil texture is predominantly sandy clay with some sandy loam soils at Bangasse, Nedogo, and Diapangou. Soils are predominantly sandy loam at Dissankuy. Sand, silt, and clay content on the Mossi Plateau range from 60-70%, 20-30%, and 5-10% respectively (Vierich and Stoop, 1984). Table 1 presents the pH, fertility, and other characteristics of the soil by village location. The soils contain only weak aggregates and after a rain the soil surface dries and forms a crust which restricts water infiltration and aeration and increases rainfall runoff (Kowal and Kassam, 1978). In the dry season the soils harden making pre-plant cultivation difficult and almost impossible by traditional methods until there is a major rain. Land quality deteriorates as one moves up the toposequence. Rainfall is highly variable and unpredictable and combined with the properties of the soil leads to water retention and soil erosion problems.

Land quality, water retention ability, and labor availability are the dominant factors in cropping decisions (Lang et. al., 1983). Maize, which is less tolerant to drought and low soil fertility than either sorghum or millet is planted near the village compound. The compound area, ranging from .1 to .2 ha is used to dump night soil, animal manure, stubble and other organic material. Thus, the amount of land suited to growing maize is limited. Sorghum is planted on the more low lying areas where there is slightly more water accumulation and where the soils are more fertile than the poorer soils further up the toposequence (Stoop et. al., 1982). The poorer land is planted to millet, which is the most drought and disease tolerant crop. Farmers say that white sorghum is preferred because it stores twice as long as millet. However, sorghum is more vulnerable to parasites (striga), drought and other diseases than is millet. Farmers say that in the worst rainfall years, some millet can always be harvested. The timing of rains also influences planting decisions; the later the rains, the more millet farmers plant. Also, farmers would plant more millet if not constrained by the labor supply in the planting, first weeding period. More cash crops such as peanuts would be planted but priority is given to the planting and first weeding of staple crops. A limited labor market exists for agricultural activities, particularly at planting and first weeding. Most farmers use their own household labor and little labor is hired in or out.

There is a distinction between collective fields of the household that provide the major subsistence crops and personal fields which individuals cultivate for private profit (Saunders, 1980). Work on collective fields takes priority over work on private fields especially in peak labor periods. Both men and women have personal fields and plant cash crops.

In general, farmers' goals on the Mossi Plateau are subsistence oriented with the most immediate goal being that of meeting their staple food consumption needs (FSU/SAFGRAD, 1983). Commercialization is at a low level in all the villages with the exception of Dissankuy. Farmers in Dissankuy are more commercialized as a result of the cotton industry in their area.

Animal traction is the only major capital investment made by farmers. It is estimated that 10% of the farms in Burkina use animal traction. Most animal traction units are acquired under animal traction programs with built-in credit arrangements. Most formal credit for purchases of agricultural inputs such as fertilizers is obtained through membership (usually the household head) in a village credit group. When farmers are

asked why they do not use more fertilizer, their response is that it is not readily available (outside the cotton growing area) and that they lack the credit (Ohm et. al., 1985a).

The increased man-land ratio on the Mossi Plateau has caused a change in the traditional farming systems in many villages. Traditionally, farmers plant land for five to seven years and then it is fallowed for up to 20 years to restore the fertility. In Nedogo and Bangasse, there is limited access to new land and virtually all land within the boundaries of the two villages has been planted without fallowing as long as the farmer can remember. The shorter fallow period in combination with the present farm management practice of burning or the removing of all plant material for household and animal feed exhausts the soil. The end result is that as more pressure is put on the land for food production, soil deterioration will increase, resulting in lower yields and lower food production.

On-Farm Trials and Socioeconomic Campaign

With regard to the factors of production, land quality (soil fertility), and labor requirements at planting and in particular at first weeding represent the most pressing constraints. The other most pressing constraint is water. If more water can be made available, the expected returns to several other factors of production (land, labor, fertilizer) will be substantially increased. A further constraint to exploiting some types of technologies is the farmers' present subsistence orientation and the low level of commercialization. Thus, to start with farmers will only be able to use technologies that use a low level of cash inputs and exploit non-cash inputs such as labor wherever possible.

FSU's field trial campaign focused part of its efforts on soil fertility and water management (FSU/SAFGRAD, 1983, Lang et. al., 1984, and Ohm et. al., 1985a). Given the continuing deterioration of the soil, the limited supply of local organic matter, and the farmers' present level of commercialization, low levels of commercial fertilizers were incorporated into the field trials. The water management technique of tied ridging was also incorporated in the trials.[5]

In 1982, on-farm researcher-managed trials on sorghum were conducted using commercial fertilizer and tied ridges constructed 30 to 35 days after planting resulting in average yield increases of 195% over traditional practices (FSU/SAFGRAD, 1983). Based on the information of the on-farm researcher-managed trials, on-farm farmer-managed trials were then conducted in 1983 and 1984 with the objective of evaluating the agronomic characteristics and economic benefits from the construction of the water conservation technique of tied ridging in association with minimal amounts of

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[5]Tied ridges are small depressions made between the crop rows either by hand tillage or with a combination of animal traction and hand tillage. If done by hand, depressions 32 cm long x 24 cm wide x 16 cm deep are made between the rows and spaced 1 1/2 meters apart. If done with animal traction, the cultivator is equipped with a middle sweep to create a furrow which is then followed by hand tillage to make a 16 cm high ridge perpendicular to the furrow every one to two meters.

fertilizer. The treatments of the trials in the four villages were as follows:[6]

1) traditional management practices (flat cultivation, no pre-plant plowing, no fertilizer),
2) construction of tied ridges at 4 to 6 weeks after seeding and no fertilizer,
3) flat cultivation and 100 kg ha^{-1} 14-23-15 fertilizer applied in a band 10-15 cm from the rows of sorghum two weeks after seeding plus 50 kg ha^{-1} urea, applied in pockets 10-15 cm from the seed pockets 4 to 6 weeks after seeding, and
4) construction of tied ridges 4 to 6 weeks after seeding plus fertilization as described above.

Rainfall in the villages was 574, 670, 666, and 668 mm in 1983 and 514, 452, 675, and 458 mm in 1984 in Bangasse, Nedogo, Dissankuy, and Diapangou respectively. The rainfall pattern in 1984 is presented in Figure 2. Both 1983 and 1984 rainfall are below the long term averages (Figure 2).

Socioeconomic data collection included collection of labor times on farmers' fields for the principal agricultural activities and labor times for the two technological interventions of tied ridging and fertilization which are used in the budget analysis in Table 2. The mean man-hour equivalent labor required above weeding for tied ridging was set at 100, 75 and 75 hours ha^{-1} for manual, donkey, and ox traction. Fertilizer application required 75 and 20 man-hour equivalent hours ha^{-1} for application in the seed pocket and banding respectively.[7]

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[6] In 1983 and 1984 the trials were conducted on medium to good sorghum land at Bangasse (25 farmers with manual tillage), at Nedogo (25 farmers with manual tillage and 25 farmers with donkey traction) and at Diapangou (25 farmers each with manual, donkey, and ox traction). In 1984, the trial was conducted for the first time in Dissankuy with 25 ox traction farmers. At Bangasse and Dissankuy, the experimental design was a randomized complete block with farmers' fields as replications. At Nedogo and Diapangou, the experimental design was a split plot with whole plots (types of traction) arranged in a completely randomized design and treatments were the subplots. Treatments were assigned to the same plots in 1984 as in 1983. Each treatment was randomly assigned to each plot. Plot sizes ranged from .05 to .12 ha with all plots in the same field of equal size. Locally grown varieties of sorghum were used. Planting in 1984 took place the week of June 1, May 25, May 15, and June 18 in Nedogo, Bangasse, Dissankuy, and Diapangou respectively. Harvest started in October and continued into December.

[7] The labor data are synthesized from FSU data for the years 1983 and 1984. The labor data, which was gathered on a farmer recall basis, showed a large variance among farmers. Although part of the variance comes from the problems of a farmer recall method, there is a large difference between labor times of farmers as noted by the field staff and time and motion studies carried out on a select group of farmers. For example, the additional time above weeding to tie ridges by donkey ranged from 50 to 125 hr ha^{-1}. The labor times used for the budget analysis in Table 2 represent that of a good farmer. For purposes of the economic budget analysis presented in Table 2, a composite labor figure was calculated using the following weights: one male hour ($\geq$ 15 years) = 1, one female hour ($\geq$ 15 years) = .75 and one child hour (< 15 years) = .5.

The ANOVA and economic budget analysis is presented in Table 2. Table 3 presents the means for effects of animal traction and/or tied ridges and fertilizer on sorghum yield for the 1984 campaign.

A survey of technology adoption by FSU cooperator farmers was conducted at the end of the 1984 campaign (Ohm et. al., 1985b). The objective of the survey was to determine the extent to which FSU cooperator farmers adopted the technologies of tied ridging, new varieties, and fertilizer on their own fields. A further objective was to identify some of the key variables that distinguish adopters of technologies from non-adopters. The results (Tables 4 and 5) indicate that adoption rates and the average hectares of technology adoption are low. Farmers commented that the primary reason for not constructing more tied ridging was lack of sufficient labor. The financial conditions of not having the cash or not being able to obtain credit were their primary reason for not using fertilizer. Fertilizer availability was also cited as a problem. Farmers were generally hesitant about trying new varieties until they could give them a good appraisal--either on a demonstration plot or on another farmer's field.

The characteristic that consistently showed the strongest relationship to adoption in all three technology cases was farm size. Other characteristics of adopters were cash crop area and good management skills which both exhibited a positive relationship. Farmers (households) controlling larger than average size land holdings are associated with adopting the technologies. Perrin and Winklemann (1976) found similar results with respect to farm size and the adoption of new varieties in countries where new variety introductions were recent. Underlying the size effect are the factors of economies of size in transactions costs of evaluating and acquiring new technologies, differences in prices for inputs and products and differences in land productivity (Perrin and Winklemann, 1976). Ruttan and Binswanger (1978) indicate that while there were differential rates of adoption by farm size and tenure for the adoption of HYV's in green revolution countries at the start, differences in the adoption rates for different farm size and tenure categories disappeared after a few years. The data collected and analyzed in the FSU adoption of technology survey corresponds to the very early stages of the typical "S" shaped adoption curve and the results agree with Perrin and Winklemann and with Ruttan and Binswanger. The widespread use of new technologies in Burkina has not taken place and it is yet to be determined whether the differences in adoption rates for different farm size categories will disappear after a few years as they did in the green revolution countries.

Technology Evaluation

Evaluation Criteria

The criteria for the evaluation of the technologies of fertilization and tied ridging were as follows: 1) technical feasibility, 2) profitability/risk, 3) the "fit" of the technology within the farming system, and 4) the intrahousehold and interhousehold relationships.

The first criteria involves answering the question of "Is the technology agronomically or technically superior to existing farm practices?" Simple budgeting analysis is used for the second criteria and the percentage of farmers who would have lost cash from any of the treatments is used as an indicator of risk. With respect to the third criteria of fit, given that the technology is technically and economically feasible, it must be established whether there are other constraints in the farming system that hold back the use of the technology, i.e., land (quality, quantity), labor availability,

credit, etc. (Sanders and Roth, 1985). The fourth criteria concerns changes in intrahousehold and interhousehold relationships from the technology intervention (McKee, 1984). Three intrahousehold relationships require analysis: 1) changes in the allocation of family labor, 2) intrahousehold resource control, and 3) the incentive structure: who benefits from and controls the output from the new technology (whether it be cash, agricultural output or more free time). Questions pertaining to interhousehold dynamics involve asking whether or not the technology intervention is accessible to all households and what are the possible income distribution consequences from the adoption of the technology.

The methodology used in criteria 3 is that of linear programming (LP) which is a whole-farm modeling technique. Simple budgeting of costs and returns (criteria 2) is generally employed to evaluate the results of field trials. These evaluations are limited in two ways (Roth et. al., 1984). First, the explicit values of land and labor in Burkina are unknown and are generally included in an ad hoc manner. Secondly, the budgeting analyses are partial, hence they ignore the substitutability of inputs on the farm and how they are allocated based on the fixed endowments and implied prices of resources. New technology needs to be considered in a whole farm context (as in linear programming) to account for the effects of constraints on availabilities of land, seasonal labor, purchases of modern inputs, and other interactions.

Evaluation of the Technologies

Technical Feasibility. The relative responses of sorghum yield to the four treatments were consistent across the four locations over the two years (Table 2). Treatments consisting of tied ridges to reduce surface runoff of rainfall, or fertilization to ameliorate the low fertility resulted in increased levels of sorghum yield. The analysis of variance indicated that when tied ridges were used in combination with fertilizer, statistically significant yield increases over the control were recorded at all locations for both years.[8]

Yields of sorghum were generally higher with animal traction than with manual traction. At Nedogo, the difference was significant only for the combination of tied ridging and fertilization (Table 3). At Diapangou, sorghum yields with ox traction were not superior to those with donkey traction. It is possible that the deeper cultivation during weeding with ox traction, compared to donkey traction, accentuated the severe drought conditions in both years, especially in sandy soils with low organic matter. In sandy soils, there exists the problem of the ties washing away under heavy rains and thus requiring extensive repair during the growing season.

The conclusions to be drawn are that the use of tied ridging alone or fertilization (at the treatment levels) alone can result in superior yields but that when used in combination, the sorghum yields are always superior.

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[8]Had new varieties been included in the treatments, the criteria would also include seedling establishment, yield stability, and yield component analysis (Matlon, 1985).

Tied ridges may not be suitable in the more sandy soils and should only be recommended in areas with soils that do not wash away easily.[9]

Profitability/Risk. The partial budget analysis (Table 2) shows that for the mean yield increases at all locations over the two years with the exception of Nedogo manual in 1983, the return hr^{-1} for labor to construct tied ridges and/or to apply fertilizer was positive. With the exception of the 1983 Treatment F in Bangasse, net returns were the largest for the combination of tied ridging and fertilization at all locations. Net returns were larger for fertilization alone than for tied ridging alone at Bangasse and for the three types of traction at Diapangou in both years. In 1984, the return hr^{-1} of additional labor for the combination of tied ridging and fertilization were larger than the return hr^{-1} of additional labor for the other treatments at Bangasse and for the two types of animal traction at Diapangou while in 1983, the return hr^{-1} was largest for fertilization at Bangasse and all Diapangou locations. With respect to the farmers' risk of losing their cash outlay, the fertilization alone treatment is high at Nedogo and moderately risky at all other locations and some farmers at each location would have lost cash. The use of tied ridging in combination with fertilization substantially reduces the farmers' risk of losing cash as opposed to the fertilization alone treatment. Because tied ridging uses household labor, the tied ridging treatment does not carry the risk of losing a cash outlay. This option results in substantially reduced net returns when compared to the tied ridging fertilization combinations and although this practice controls erosion, it cannot solve the low soil fertility problem.

The conclusions to be drawn are that tied ridging alone or fertilization alone can be profitable; however, fertilization alone carries a high risk of losing the cash outlay. Only when in combination do the two technologies provide substantial net return and return hr^{-1} of additional labor at a level of risk of losing the cash outlay that may be acceptable to farmers.

Technology "Fit". Linear programming was used to analyze the technology interventions within a whole farm context.[10] Three models were constructed representing the three types of tillage practices on the Mossi Plateau: manual only tillage, donkey traction, and ox traction. The technology interventions of tied ridges and fertilization were incorporated into the models. Tied ridging was given as an option on maize compound land and tied ridging and fertilization were options on the two types of sorghum land and on the millet land. On-farm researcher-managed trials indicated a significant

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[9] Of a total cultivated area of 2,005,000 ha in Burkina Faso, it is estimated by local agronomists that about 40% is suitable for tied ridging based on land quality and rainfall levels.

[10] Briefly, the linear programming (LP) farm model has the option of performing tillage operations under one of three types of tillage practices: manual, donkey, and oxen. A farmer possesses four types of resources: land of various quality, family labor, animal traction, and modern inputs. Land is divided into four types: high fertility compound land, two types of sorghum land with one having better fertility and water retention capability and the fourth, the lower quality millet land. Stocks and flows of labor are disaggregated into weekly time periods to capture the critical labor constraints at planting and first weeding. Information on the technical aspects of the tied ridging and fertilization technologies from the on-farm trials and socioeconomic surveys are included in the LP model.

maize yield response from tied ridges alone but little additional response when fertilizer was added in combination with tied ridges on compound land (Lang et. al., 1984). Thus, only the tied ridging option is available for maize on compound land.

Models were run for all three types of tillage. Results are only shown for the donkey traction model given the option of using the two technologies in combination and not separately (Table 6). The results of the manual tillage model indicated that the hectarage devoted to the technologies was very low. The labor constraint and the lower yields associated with manual traction precluded a significant area from being devoted to the technologies. The ox traction model showed similar results to that of the donkey traction model. When the tied ridging alone alternative is modeled, the lower yields associated with this technology as compared to the yields when used in combination with fertilizer precluded a significant hectarage from being brought into the solution. The alternative of modeling fertilizer alone was not considered because of the high risk of losing the cash outlay.

Table 6, column 1 presents the results of the donkey traction model under traditional management practices and column 2 presents the results with the technology interventions of tied ridging (ridged with donkeys but tied by hand) and fertilization.[11] The results indicate that tied ridges are constructed on maize on compound land and tied ridges and fertilization are used on all the red sorghum land (high quality sorghum land) and a small portion of the white sorghum land (lower quality sorghum land). The results also indicate that the new technologies do not completely displace the total hectarage under traditional management practices because of the labor constraint. Total per capita cereal production increases from 150 to 186 kg and net farm income per worker increases from 30.8 to 36.2 thousand CFA.

The model was run with several tied ridging labor times to examine the sensitivity of the results and take into consideration that labor times vary from farmer to farmer (as was indicated by the labor data collected in the field). Scenarios were also run with the yields of the new technologies increased by 10%. The results are presented in Figure 3 showing net farm income under a range of tied ridging labor times. The results indicate that farmers who are able to construct tied ridges with the least amount of labor time obtain a significantly higher net return. For example, the results from the model indicate that when it takes 125 hr ha^{-1} to construct tied ridges, no white sorghum land is devoted to the technologies and red sorghum land technology adoption is decreased to .5 ha.

The conclusions to be drawn from the LP model are that the two technologies can fit into the production system of animal traction farmers but that a labor constraint still prevents the technologies from being adopted on all the hectarage. The results also indicate that manual tillage farmers would adopt the technologies to a lesser extent than animal traction farmers.

Intrahousehold and Interhousehold Relationships. Under traditional cultivation, men, women, and children are involved in planting, and first and

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[11] The basic structure and data of the model is outlined in Roth et. al., 1986. The traditional management yields in kg ha^{-1} and those obtained under the technology options in the donkey traction model are as follows: maize on compound land (1090 to 1730), red sorghum on high quality sorghum land (672 to 1236), white sorghum on lower quality sorghum land (472 to 913), and millet on poor quality millet land (320 to 660). The yields are based on FSU field trial data (Lang et. al., 1983 and Ohm et. al., 1985).

second weeding. The technology interventions of constructing tied ridges and fertilization requires additional labor. The labor data collected during the field campaign indicated that the gender distribution of labor for the new tasks generally followed that of the distribution of labor for the traditional activities of planting, and first and second weeding. Thus, the gender distribution of labor with the introduction of tied ridges and fertilization does not appreciably change, however the additional labor must be pulled from other tasks or leisure and/or there must be a rearrangement of tasks to fit the labor profiles. The linear programming results indicate that with traditional donkey tillage the binding labor constraints are during planting and first weeding. There is, however, some available labor in the model during second weeding and this labor is used for making tied ridges. Thus, the additional labor for tied ridging is pulled from non-production activities or leisure.

The technological intervention of fertilization requires a cash outlay and the fertilizer is often bought through credit. Credit is usually obtained through village credit groups whose members are predominantly male household heads (Ohm et. al., 1985a). Admittance to the group requires group approval and an entrance fee. This may preclude the use of fertilizer alone or in combination with tied ridging on both men's and women's personal fields. The degree to which other economic and social features constitute barriers to entry into village credit groups requires further study. Labor is also controlled in the household. The extent to which labor would be taken away from other tasks or from work on personal fields by tied ridging and fertilization of the main fields which has priority in labor requires further study.

The main output from the technology intervention is increased agricultural output which may be used for consumption or marketed. The household heads who control the resources of production on the main fields also control the output. Other members of the household may benefit indirectly through increased consumption or cash income, but this depends on the distribution of the new production. Whether the increased output will be distributed as in the past according to current goals and objectives of the household, or will benefit only a small minority of the family remains unknown.

Changes in interhousehold distribution of income may occur from the adoption of the technology interventions. The LP results indicated that animal traction farmers will be the adopters of the technologies to a greater degree than manual tillage farmers primarily because of the labor constraint. Manual tillage farmers may, however, adopt the technologies but on a smaller hectarage. Income distribution changes may also occur if all households do not have access to credit.

Modifications to the Research Program

The LP model results, the questionnaire on the adoption of technologies, and farmer interviews throughout the three years of field trials clearly indicated that if the labor requirement for tied ridging could be decreased, more hectarage would be devoted to the technology. This had been communicated to other researchers within SAFGRAD and in the Fall of 1983, a Peace Corps volunteer with IITA/SAFGRAD in Burkina (Jeff Wright) started work on a prototype mechanical device to tie the ridges. The mechanical device is attached to an animal drawn cultivator with one large middle sweep and either ties the ridges as they are made or ties the ridges after the field has been ridged by making a second pass with the mechanical ridge tier attached to the cultivator. The device is essentially a paddle wheel (45 cm in diameter) with

four paddles, one scraping the ground building up earth until it is tripped by the operator every 1 1/2 to 2 m to create the tie in the ridge. When oxen are used, the ridging and tieing with the mechanical ridge tier can be done in one operation. Donkeys can do both operations at one time but only if they are managed well, healthy and in good condition and the soil is loose or moist. Preliminary cost estimates of the mechanical ridge tier is beteeen 10,000 and 15,000 CFA (as compared to a cultivator at a cost of 20,000 to 25,000 CFA).

With FSU collaboration, the mechanical ridge tier is part of the national farming systems on-farm field program of Burkina. A trial with a similar protocol to the farmer-managed sorghum with tied ridges and fertilization experiment is being conducted. The treatments are as follows: 1) a control (no tied ridges), 2) tied ridging with the ridge being tied by hand, 3) tied ridging with the mechanical ridge tier at second weeding, and 4) tied ridging with the ridge tier at both first and second weeding. All treatments are fertilized with 100 kg ha^{-1} 14-23-15 and 50 kg ha^{-1} urea applied at the same times as the farmer-managed sorghum trials. Yield data are not yet available but field observations indicate that they will be similar to yields obtained when the ridges are tied by hand. Labor times have been collected from the field. Ridging and tieing with the mechanical ridge tier at the same time (one pass) adds only a minimal amount of time over that of just ridging. In the model, 2 hrs ha^{-1} are given to this activity. If the donkey cannot do the operation in one pass, the additional time it takes to make the second pass to tie the ridges takes between 7 to 15 hrs ha^{-1}. Two people usually work with the donkey, thus the actual albor hours are doubled. In the model, 20 hrs ha^{-1} are used for a second pass. In the trials, urea is banded and covered by the ridger at second weeding instead of being put into pockets thus decreasing the labor requirement from 75 to 20 hr ha^{-1}.

The LP model results using the mechanical ridge tier at second weeding are presented in Table 6. Column 3 presents the results when two passes are required (ridging first followed by tieing with the mechanical ridge tier). All the red sorghum and white sorghum land are ridged and tied including a small proportion of millet land. Column 4 presents the results when only one pass is used to ridge and tie and results in a greater proportion of millet land devoted to the technologies. Figure 4 presents net farm income under a range of labor times using the mechanical ridge tier in two passes along with two yield scenarios. The one pass option under the two yield scenarios is also presented. Substantial net farm income can be gained if the donkey is able to do the operation in one pass or if the hrs ha^{-1} it takes to do two passes can be decreased to 10 hrs ha^{-1}.

The mechanical ridge tier requires animal traction and thus similar concerns to those already expressed about the adoption of tied ridges and fertilization by manual tillage versus animal traction farmers and the intrahousehold and interhousehold questions are relevant. The mechanical ridge tier may make animal traction more profitable thus more practical for adoption by present manual tillage farmers. At present, animal traction is land using allowing farmers to do more weeding and hence increase the area farmed. Through the use of the mechanical ridge tier in combination with fertilizer, animal traction can be land augmenting in that increased production can be obtained from increased yields ha^{-1}. This type of technology intervention is required in those areas where access to land is limited or in areas where extensification with animal traction leads farmers to farm more marginal land (Roth and Sanders, 1984).

Conclusions and Policy Recommendations

The water retention and fertility research results indicate that the combination of tied ridging and fertilizer (14-23-15 and urea) is both technically and economically superior to traditional management practices. When only one of the technologies is used, yields are constrained by the absence of the other and in the case of fertilizer alone, the risk of losing the cash outlay is very high as observed by the results in Table 2. When the two technologies are used in combination, the next constraint is labor availability. While manual farmers may adopt the two technologies on a small portion of their land, animal traction farmers are in a better position to be adopters because they can construct tied ridges faster and better (resulting in higher yields) than manual tillage farmers. Labor is still a constraint for animal traction farmers when the ridges are tied by hand. The results indicate that the mechanical ridge tier can decrease the labor constraint to the point where most of the staple crop land is under tied ridges.

Before farmers will adopt the tied ridges and fertilization package on a large scale and before the technologies are fully recommended, several issues must be dealt with. The first issue is that the technology package will be adopted to a greater extent by animal traction farmers and those animal traction farmers who have access to credit for fertilizer and the mechanical ridge tier. At present, not all members within a household or all households have access to credit or animal traction. The policy implications are that credit and animal traction programs are required to make access more readily available to those involved in agricultural production. Also, the mechanical tied ridger can make animal traction more profitable thus giving the opportunity to increase the use of animal traction in Burkina. This, however, would require animal traction programs on a large scale to train animals and to train farmers in management and maintenance and make animals, equipment, and credit available. At present, there are also problems of fertilizer availability outside of the cotton growing area and strategically placed distribution centers are required before fertilizer use by farmers will increase.

The field trial results indicated that tied ridgers do not work as well in sandier soils especially in the more northern areas. Recommendations as to the soil types and areas that are suitable for tied ridging as well as other water retention methods (diguettes) and soil tillage practices need to be made.

The LP results indicate that tied ridging and fertilization technologies would have a better chance of being adopted if yields can be improved through plant breeding. For example, the shift in the yields by 10% in Figures 3 and 4 demonstrate a significant increase in net returns. In the near future, it cannot be expected that farmers will be able to provide high levels of management within which the improved varieties to date do their best. The FSU research has shown that the use of an intermediate level of inputs such as tied ridging and minimal amounts of fertilizer can be profitable using local varieties. In addition to screening varieties under high management levels, it is within this intermediate input level environment that screening for better plant varieties would have the most immediate payoff.

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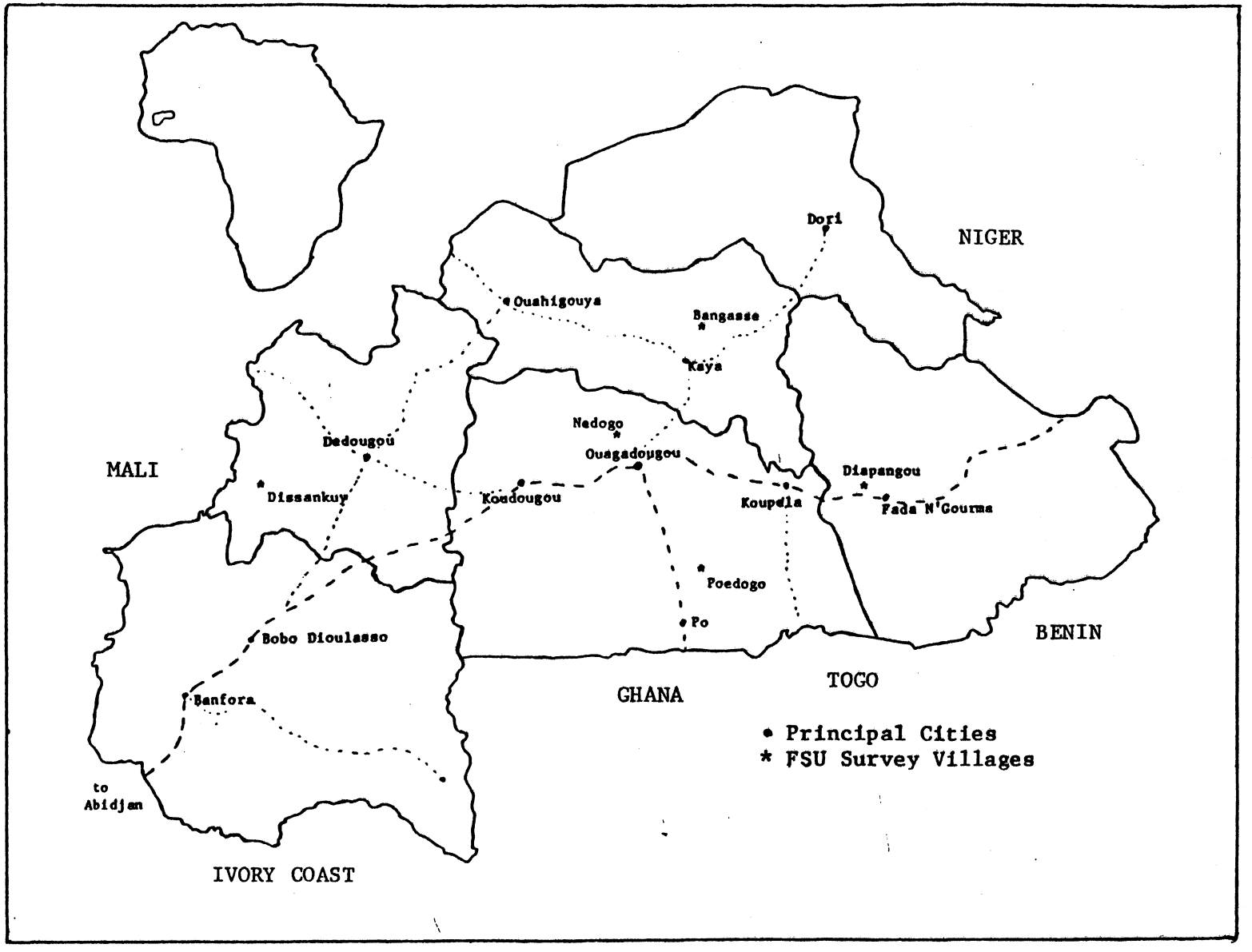


Figure 1: Map of Burkina Faso

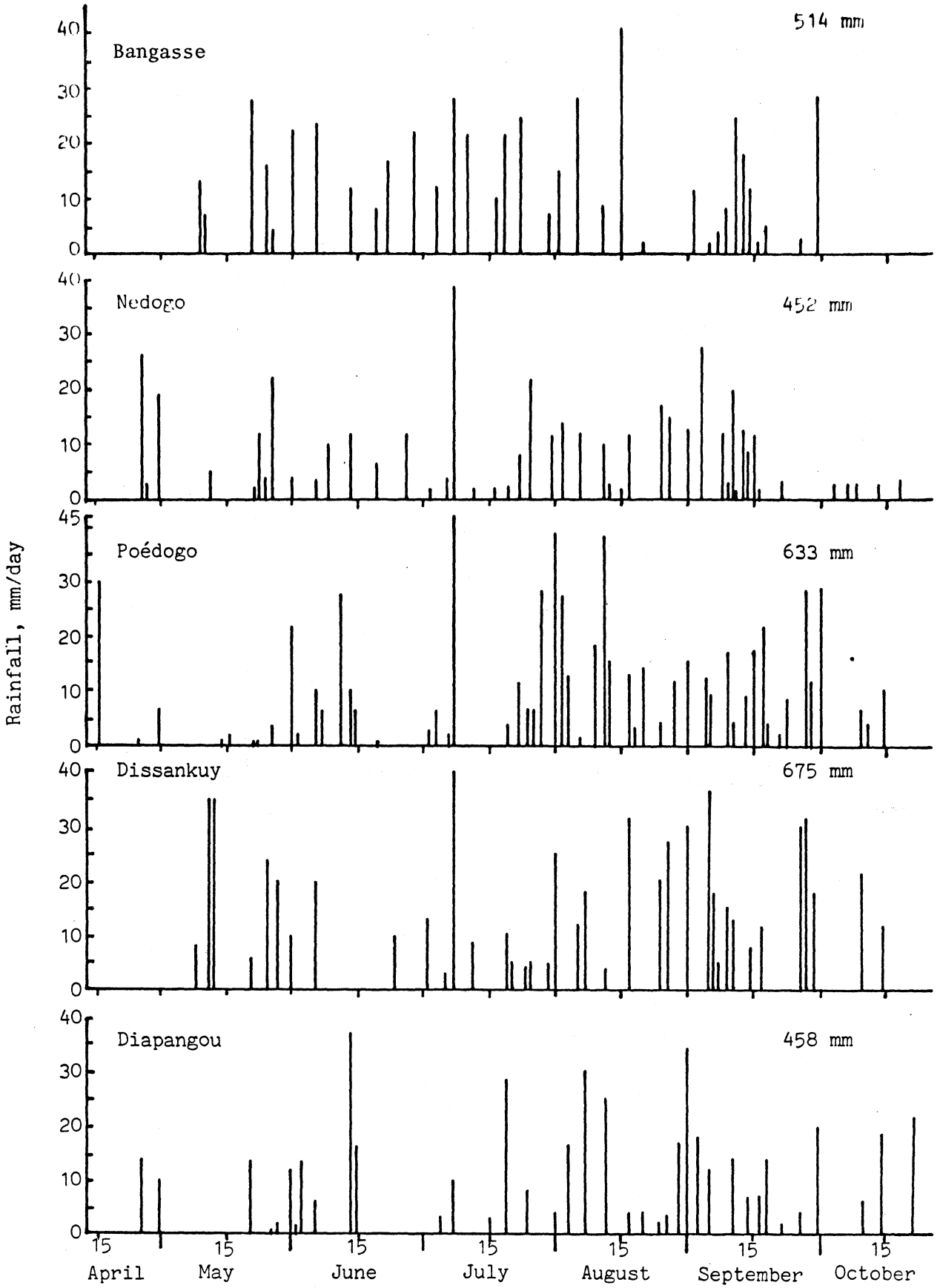


Fig. 2. Rainfall at five villages in Burkina in 1984. Total seasonal rainfall at each of the five villages is indicated near the right side of the figure. Average annual rainfall at data collection sites near the five villages (Bangasse, Nedogo, Poédogo, Dissankuy, Diapangou) are respectively (mm), the number of years of data until 1977 are in parentheses: Kaya, 703 (59); Pabre, 809 (24); Manga, 905 (29); Solenzo, 903 (18) and Fada N'Gourma 865 (58) (ICRISAT, In Press). (Source Ohm et al., 1985a)

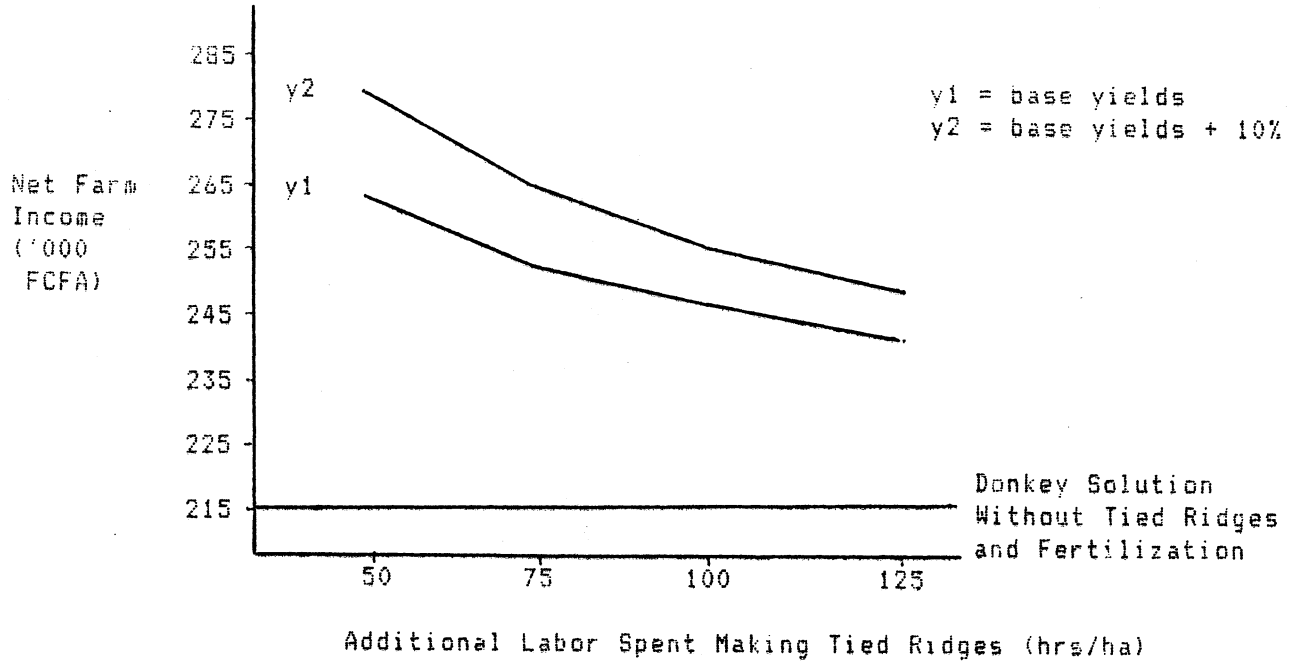


Figure 3. Effect of various yields and labor spent on tied ridging by hand on net revenue of the farm on the Central Plateau.

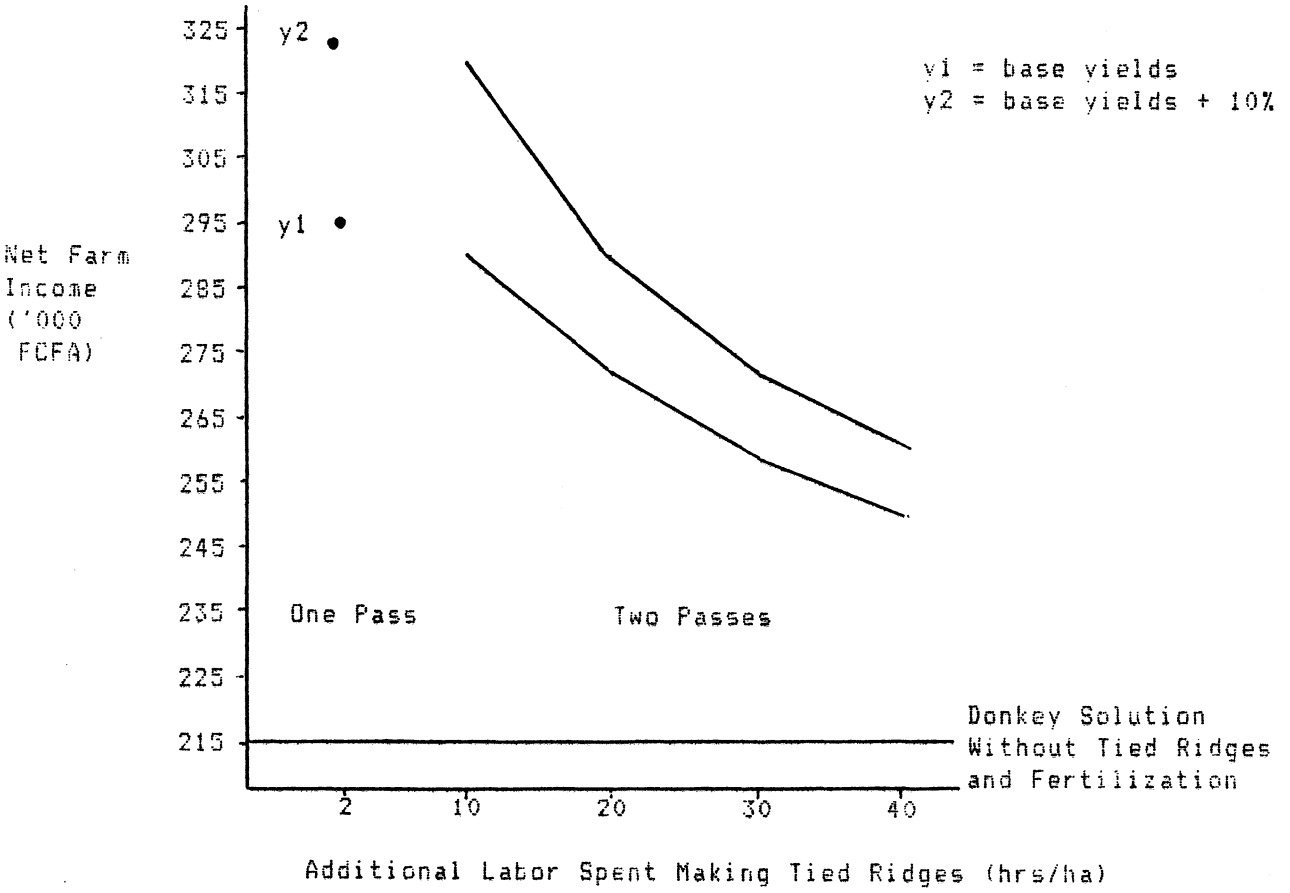


Figure 4. Effect of various yields and labor spent on tied ridging with machine on net revenue of the farm on the Central Plateau.

Table 1. Soil Characteristics of Five FSU Villages in Burkina Faso.

Village Location[1]	pH Water	Organic Matter	Base Saturation	P	K	Ca	Mg	Cation Exchange Capacity
		%		kg/ha				
Diapangou	6.7	1.07	74.6	20	307	1968	409	5.9
Dissankuy	5.9	1.79	56.7	7	230	1190	357	8.1
Bangasse	5.9	1.09	61.9	5	228	988	305	5.8
Poedogo	6.4	0.73	71.3	24	318	1250	321	4.3
Nedogo	6.3	1.01	62.3	12	273	1168	232	4.3

Source: Ohm et al. 1986. Soil nutrient content in Burkina Faso. Purdue University Research Bulletin. Forthcoming.

[1]Soil Samples taken from on-farm farmer-managed control plots in each village.

Table 2. Economic analysis of farmer managed trials of sorghum with fertilizer and tied ridges, 1984.

	Treatments 1/						Number
	C	TR	F	TR.F	S.E 4/	CV 4/	of Farmers
Nedogo, Manual Traction							
Grain Yield, kg/ha	157	416	431	652	75.1	43	11
Yield Gain Above Control, kg/ha	-	259	274	495			
Gain in Net Revenue, CFA 2/	-	23828	13275	33607			
Return/hr. of Additional Labor, CFA 3/	-	238	140	172			
% Farmers Who Would Have Lost Cash	-	0	27	9			
Nedogo, Donkey Traction							
Grain Yield, kg/ha	173	425	355	773	63.4	44	18
Yield Gain Above Control, kg/ha	-	252	182	600			
Gain in Net Revenue, CFA	-	23184	4811	43267			
Return/hr. of Additional Labor, CFA	-	309	51	255			
% Farmers Who Would Have Lost Cash	-	0	50	0			
Bangasse, Manual Traction							
Grain Yield, kg/ha	293	456	616	944	145.0	62	12
Yield Gain Above Control, kg/ha	-	163	323	651			
Gain in Net Revenue, CFA	-	14996	17783	47959			
Return/hr. of Additional Labor, CFA	-	150	187	246			
% Farmers Who Would Have Lost Cash	-	0	8	17			
Dissankuy, Ox Traction							
Grain Yield, kg/ha	447	588	681	855	35.1	19	25
Yield Gain Above Control, kg/ha	-	141	234	408			
Gain in Net Revenue, CFA	-	12972	9595	25603			
Return/hr. of Additional Labor, CFA	-	173	101	151			
% Farmers Who Would Have Lost Cash	-	0	28	0			
Diapangou, Manual Traction							
Grain Yield,kg/ha	335	571	729	1006	48.4	23	19
Yield Gain Above Control, kg/ha	-	236	394	671			
Gain in Net Revenue, CFA	-	21712	24315	49799			
Return/hr. of Additional Labor, CFA	-	217	256	255			
% Farmers Who Would Have Lost Cash	-	0	26	0			
Diapangou, Donkey Traction							
Grain Yield, kg/ha	498	688	849	1133	45.6	18	19
Yield Gain Above Control, kg/ha	-	190	351	635			
Gain in Net Revenue, CFA	-	17480	20359	46487			
Return/hr. of Additional Labor, CFA	-	233	214	273			
% Farmers Who Would Have Lost Cash	-	0	21	0			
Diapangou, Ox Traction							
Grain Yield, kg/ha	466	704	839	1177	46.8	18	19
Yield Gain Above Control, kg/ha	-	238	373	711			
Gain in Net Revenue, CFA	-	21896	22383	53479			
Return/hr. of Additional Labor, CFA	-	292	236	315			
% Farmers Who Would Have Lost Cash	-	0	5	0			

1/ C = control (no tied ridges or fertilizer); TR = tied ridges constructed one month after seeding; F = 100 kg/ha 14-23-15 two weeks after seeding plus 50 kg/ha urea one month after seeding.

2/ Net revenue = yield gain x grain price (92 CFA/kg) minus fertilizer cost; (78 CFA/kg for 14-23-15, and 66 CFA/kg for urea), Includes interest charge for six months at rate of 15%.

3/ Net revenue/additional labor of tied ridging and fertilizer application. Manual, Donkey, and Ox traction require 100, 75, and 75 hours of additional labor/ha for tied ridging respectively. Fertilizer application requires 95 additional hours/ha.

4/ S.E. = the standard error of the difference between two treatment means. CV% = coeficient of variation.

Table 2 (con't). Economic analysis of farmer managed trials of sorghum with fertilizer and tied ridges, 1983.

	Treatments 1/						Number
	C	TR	F	TR,F	S.E. 4/	CV 4/	Farmers
			Nedogo, Manual Traction				
Grain Yield, kg/ha	430	484	547	851	121.9	29	3
Yield Gain Above Control, kg/ha	-	54	117	421			
Gain in Net Revenue, CFA 2/	-	4968	-1169	26799			
Return/hr. of Additional Labor, CFA 3/	-	50	-	137			
% Farmers Who Would Have Lost Cash	-	0	56	0			
			Nedogo, Donkey Traction				
Grain Yield, kg/ha	444	624	604	962	128.7	49	11
Yield Gain Above Control, kg/ha	-	180	160	518			
Gain in Net Revenue, CFA	-	16560	2787	35723			
Return/hr. of Additional Labor, CFA	-	221	29	210			
% Farmers Who Would Have Lost Cash	-	0	58	42			
			Bangasse, Manual Traction				
Grain Yield, kg/ha	406	493	705	690	94.8	46	12
Yield Gain Above Control, kg/ha	-	87	299	284			
Gain in Net Revenue, CFA	-	8004	15575	14195			
Return/hr. of Additional Labor, CFA	-	80	164	73			
% Farmers Who Would Have Lost Cash	-	0	21	17			
			Diapangou, Manual Traction				
Grain Yield,kg/ha	363	441	719	753	37.6	23	24
Yield Gain Above Control, kg/ha	-	78	356	390			
Gain in Net Revenue, CFA	-	7176	20819	23947			
Return/hr. of Additional Labor, CFA	-	72	219	123			
% Farmers Who Would Have Lost Cash	-	0	8	8			
			Diapangou, Donkey Traction				
Grain Yield, kg/ha	481	552	837	871	43.5	22	25
Yield Gain Above Control, kg/ha	-	71	356	390			
Gain in Net Revenue, CFA	-	6532	20819	23947			
Return/hr. of Additional Labor, CFA	-	87	219	141			
% Farmers Who Would Have Lost Cash	-	0	12	16			
			Diapangou, Ox Traction				
Grain Yield, kg/ha	526	578	857	991	50.8	24	25
Yield Gain Above Control, kg/ha	-	52	331	465			
Gain in Net Revenue, CFA	-	4784	18519	30847			
Return/hr. of Additional Labor, CFA	-	64	195	181			
% Farmers Who Would Have Lost Cash	-	0	20	12			

1/ C = control (no tied ridges or fertilizer); TR = tied ridges constructed one month after seeding; F = 100 kg/ha 14-23-15 two weeks after seeding plus 50 kg/ha urea one month after seeding.

2/ Net revenue = yield gain x grain price (92 CFA/kg) minus fertilizer cost; (78 CFA/kg for 14-23-15, and 66 CFA/kg for urea), Includes interest charge for six months at rate of 15%.

3/ Net revenue/additional labor of tied ridging and fertilizer application. Manual, Donkey, and Ox traction require 100, 75, and 75 hours of additional labor/ha for tied ridging respectively. Fertilizer application requires 95 additional hours/ha.

4/ S.E. = the standard error of the difference between two treatment means. CV% = coeficient of variation.

Table 3. Means for effects of animal traction and/or tied ridges and fertilization on grain yield of sorghum grown at five villages in Burkina Faso in 1984[1].

Treatments	Mean grain yield			
	Nedogo	Bangasse	Dissankuy	Diapangou
	kg/ha			
Traction				
Manual	414.3	—	—	660.2
Donkey	497.6	—	—	792.1
Ox	—	—	—	797.0
SE[2]	39.1	—	—	72.9
TR[3] F[4]				
Control[5]	185.5	293.1	447.0	433.0
TR	446.1	456.0	587.7	654.5
F	441.2	615.8	680.8	805.6
TR and F	750.9	943.6	855.4	1105.6
SE[2]	78.1	145.2	35.1	51.7
CV%	56.8	61.6	19.3	36.8
N[6]	11	12	25	19

[1]Local varieties of white sorghum at Nedogo, Bangasse and Dissankuy, and a mixture of local millet (85%) and local white sorghum (15%) at Diapangou.
[2]Standard Error of the difference between two treatment means.
[3]TR = tied ridges, constructed one month after planting.
[4]F = fertilization, 100 kg/ha cotton fertilizer, 14-23-15, was applied in a band at 10 to 15cm from the rows of sorghum two weeks after planting and 50 kg/ha urea was applied in pockets at 10 to 15cm from seed pockets one month after planting.
[5]Without tied ridges or fertilization.
[6]The number of farmers' fields, replications, on which the experiment was grown.

Source: Ohm et al., 1985a, p. 12.

Table 4. Percent of farmers adopting tied ridges (TR), fertilizer and new varieties by village, 1984.

Village	Years[1]	Number of Farmers	Percent of farmers adopting		
			TR	Fertilizer	Varieties
Nedogo	5	69	25	10	10
Bangasse	3	53	23	0	0
Poedogo	2	27	4	33	41
Dissankuy	2	60	3	97[2]	0
Diapangou	3	61	25	8	8

[1]Number of years FSU in village; 1984 was the first year for farmer-managed trials at Poedogo and Dissankuy.
[2]The figures relate only to land sown to cotton. Small amounts of fertilizers are used on cereals.

Source: Ohm et al, 1985b.

Table 5. Average hectares of technology adoption, 1984.

Technology	Village				
	Nedogo	Bangasse	Poedogo	Dissankuy	Diapangou
	ha				
Tied ridges	.32	.03	.11	.03	.18
Fertilizer	.46	0	3	3	.34
Varieties	.33	0	.12	0	.04

Source: Ohm et al., 1985b.

Table 6. Effect of Tied Ridging Technologies with Donkey Traction on Area Cultivated, Production and Net Farm Income Estimates, Central Plateau

Variable	Traditional Management (Donkey)	Tied-Ridging Technology a/		
		Tied by Hand	Tied With Machine	
			Two Passes	One Pass
Total Area Cultivated (ha)	5.5	5.6	5.7	5.6
Maize				
Traditional	.20			
With Tied Ridges		.20	.15	.15
Red Sorghum				
Traditional	.60			
With Tied Ridges		.60	.68	.60
White Sorghum				
Traditional	.80	.70		
With Tied Ridges		.10	.80	.95
Millet				
Traditional	3.18	3.15	3.18	1.88
With Tied Ridges			.05	1.27
Peanuts	.76	.86	.79	.71
Fertilizer (kgs/farm)				
Urea		45	84	149
Cotton Fertilizer		90	168	298
Total Cereals Production (kgs)				
Per Household	2103	2604	2970	3354
Per Resident b/	150	186	212	240
Net Farm Income ('000 FCFA) c/				
Per Household	215.3	253.2	273.2	296.4
Per Worker d/	30.8	36.2	39.0	42.3

a/ Based on 50 kg/ha Urea and 100 kg/ha Cotton Fertilizer, labor times of 75 hrs/ha for Tying the Ridges by Hand, 20 hrs/ha for Machine--Two Passes, and 2 hrs/ha for Machine--One Pass. Yield estimates are given in text.
b/ Based on 14 residents/household.
c/ Annualized cost of 4,400 FCFA for Tied-Ridging Machine subtracted in columns 3 and 4.
d/ Based on 7 active workers/household.

IMPACT OF CROPPING SYSTEMS PROGRAM AT SUKCHAINA, NEPAL

B. K. Singh and K. D. Sayre

INTRODUCTION

Located in the Parsa District in Nepal, Sukchaina is a village of approximately 100 households and 150 ha of cultivated land, surrounded by a network of irrigation channels. These channels are useless to the farmers of Sukchaina because they are designed to deliver irrigation water to adjoining areas. Because of its location and topography, Sukchaina has been by-passed, left as an island of rainfed agriculture. It is representative of thousands of hectares of rainfed, rice-growing lands in Nepal's Terai area. In 1977, the Cropping Systems Program selected Sukchaina Village, one of a network of sites in Nepal, as an appropriate location to test new crop production technologies for the rainfed areas of the Terai.

The Cropping Systems Program has implemented a novel approach to identify improved crop production technologies in several well-defined socio-agroclimatic situations in Nepal. The approach strives to bring together biological scientists, social scientists, and farmers to work together as a team in farmers' fields to identify improved practices to increase crop production and economic well-being. After developing a thorough understanding of the conditions that exist within the area encompassed by the Cropping Systems Research site, research trials are designed and implemented with full participation of carefully selected farmers to test new innovations and to evaluate their utility.

The Cropping Systems Approach seeks to elevate farm income by increasing total crop production of farms through identification of innovations that are compatible with the agronomic and climatic conditions, the farm resources base (capital, labor, power, and management capability), and the existing cropping systems. This differs greatly from traditional commodity based research and production approaches which focus on increasing the yield of a single crop such as rice, wheat, maize, etc.

The Cropping Systems Approach strives to increase total crop production per year of farms by improving crop performances in the predominant, existing cropping patterns, or by increasing the intensity of land use by adding additional crops to the existing patterns, or by a combination of both approaches. Biological scientists are aware of recent technological advances available from the various commodity programs and research disciplines. Social scientists help to decide which technologies to try by developing a "screen" selecting relevant technologies worthy for test. The selection is based on their knowledge and developed through observation, surveys, and interviews of farmers regarding the prevailing conditions within the site. The selected farmers agree to try these technologies in their fields in cropping patterns and component technology trials and pass judgment on the feasibility of the innovations. Once useful new technologies are identified, they are extended to farmers within the site and to farmers in other similar areas.[1]

This approach has been followed at Sukchaina and other Cropping Systems Research sites. This report documents the success of the Cropping Systems Program and the Sukchaina farmers who have achieved improved crop production.

METHODOLOGY

The seven years that the Cropping Systems Program has spent in Sukchaina can be divided into two broad periods: 1977 to 1980 (Research Phase), and 1980 to present (Research and Extension Phase). Throughout this time, surveys have been conducted to determine what changes have been taking place.

The first survey, conducted in 1977, was a reconnaissance to describe the existing situation before the research phase was initiated. This survey was instrumental in helping the researchers plan the initial trials that were established. It also forms a baseline for measuring changes that are observed in succeeding surveys. The initial survey indicated that (1) 95% of the cultivated area in Sukchaina was rainfed, (2) the average land holding was 0.83 ha per household, (3) over 50% of the cultivated area was under a rice monocrop, and (4) numerous local rice varieties were being grown over 80% of the rice area. The farm size distribution was as follows:

Farm Size (ha)	% of Household
Landless	5.2
0 - 1.5	63.8
1.5 - 3.0	20.2
3.0 and above	10.4

In 1981, coinciding with the beginning of the research and extension phase, a parcel to parcel survey of 122 parcels belonging to 40 farmers was conducted. This survey sought information about cropping patterns being followed, crop varieties, crop yields, fertilizer application, availability of irrigation, plus several other factors about each parcel. In 1984, a second survey using basically the same questionnaire was conducted with the same 40 farmers concerning the same 122 parcels (one parcel had been sold). In addition, in 1984 a Key Informant Survey was conducted with five knowledgeable Sukchaina farmers concerning the current agricultural situation in their village. This report compiles and summarizes the results of these three surveys, emphasizing those conducted in 1981 and 1984.

RESULTS AND DISCUSSION

The main criteria that have been used to illustrate changes in crop production strategies that have occurred at Sukchaina are changes in rice varieties, fertilizer application to rice, rice yields, cropping patterns, and cropping intensity measured by Land Utilization Index (LUI) and Multiple Cropping Index (MCI).

Rice Varieties

The reconnaissance survey and other observations during 1977 indicated that many different local varieties were being grown in Sukchaina. Each local variety had defined characteristics recognized by farmers. For example, Anandi had good popping quality; Basmati had very fine, aromatic grain and good straw yield; Kasturi had fine aromatic grain; and Handiful was somewhat drought tolerant and had comparatively good grain and straw yield under minimum inputs. All were generally low in grain yield and most were late in maturity. Farmers tended to grow specific varieties in association with certain cropping patterns and land types.

The Cropping Systems Researchers realized at the onset that it would be necessary to test and identify several improved rice varieties to adapt to existing cropping patterns and land types or for use in new alternative patterns. No single improved variety would fit all situations. Farmers not only considered grain yield but also maturity to fit certain patterns, straw yield, threshing characteristics, grain characteristics for consumption and marketing, and certain other factors. Emphasis was given to identifying sound improved varieties that were earlier than most of the locals. The strategy was to make better use of residual moisture from the monsoon rain through earlier rice harvest, to allow planting of winter crops at the appropriate time, and to spread peak labor requirements.

In 1977, 80% of the area was planted to local varieties and 20% was planted to the two existing improved varieties, Masuli and CH-45. By 1981, after 4 years in the research phase, 54% of the area was planted to four improved varieties versus 46% for local varieties. Bindeshwari and Malika had been identified in the research as promising, and these varieties were spread by farmer-to-farmer seed sale or exchange.

Extension activities were initiated in 1980 (winter season), thus the period from 1980 to 1984 reflects the impact of this extension effort. By 1984, 98% of the rice area in Sukchaina was planted to improved varieties, including a still wider spectrum of improved varieties. Of the 122 parcels that were surveyed in 1981 and 1984, only 3 parcels (2%) were planted to local varieties in 1984. The research activities that continued during the 1981 to 1984 period have continued to identify additional new varieties, and both IR 8423 and Saryu-49 are entering into general production. In fact, the Sukchaina farmers have over 2000 kg of seed available for sale or exchange.

This, in fact, has been a curious side effect of the program at Sukchaina. The key farmers have become recognized as a source of rice seed

of new, high-yielding varieties for rainfed conditions. Farmers from other areas come to them to buy seed of the new varieties. More than 19,000 kg of improved variety seed was sold in 1984 or available for sale during 1985, including 14,800 kg of Bindeshwari. The Key Informant Survey in 1984 indicated that seed had been sold or given to farmers from other areas in Parsa District and from Bara, Rautahat, Sarlahi, Mahottari, Dhanusha and Chitwan Districts, and also from India.

Fertilizer Application to Rice

The Cropping Systems Program has followed an integrated approach to developing relevant fertilizer recommendations for the important cropping patterns in all the Cropping Systems Research sites. The approach has involved determining economically feasible fertilizer rates for each crop in the farmers' cropping patterns and potential residual effects. In Sukchaina, the findings have shown no economic response to application of K on rice. Similarly, there has been no economic response to applying P to rice if P is applied to a winter crop at the rate of 20-30 Kg ha^{-1} P_2O_5 before rice is planted.

These findings have guided farmers in Sukchaina to establish economic priorities in buying fertilizer for their cropping patterns and have helped to maximize use of scarce capital resources. Recommendations that have been developed for Sukchaina commonly involve only N for rice; N, P, and, where relevant, K, are applied to succeeding winter crops. Residual effects of P and K applied to the winter crops appear to provide sufficient amounts for the following rice crop, at least at the current N levels recommended for rice.

Changes in N application to rice have been spectacular. Average N applied to local varieties in 1981 was 23 kg ha^{-1}. In 1984, out of the 122 parcels surveyed, only three parcels were planted to local varieties. Average N application to these parcels was 30 kg ha^{-1}, a modest increase as compared to 1981. Average N application to improved varieties of rice in 1981 was 27.7 kg ha^{-1}. This increased to 40.2 kg ha^{-1} in 1984, an increase of 45%. In 1981, 25% of the surveyed parcels (involving both local and improved varieties) did not receive any chemical fertilizer. This dropped to zero in the 1984 survey.

Most farmers were applying N as both basal and top-dress in 1984, as recommended by the Cropping Systems Program, whereas in 1981 most farmers were applying N only as top-dress. Compost application practices to rice remained almost the same comparing the survey results for 1981 and 1984, with about 60-65% of the parcels receiving just over 2 t ha^{-1} of compost. The results clearly indicate that there have been marked changes in the rates of N application to rice between 1981 and 1984 at Sukchaina. This has coincided with the rapid increase in the area planted to improved rice varieties, and the farmers must have decided that these increased rates were an economically viable practice.

Rice Yields

The surveys conducted in 1981 and 1984 questioned farmers about the rice yields obtained in each survey parcel. In 1981, the average yield of local varieties was 1.47 t ha^{-1}. In 1984, in the three parcels in which local varieties had been planted, the average yield was 1.40 t ha^{-1}, essentially the same. The situation for improved varieties was strikingly different. Average yield of improved varieties in 1981 was 1.73 t ha^{-1}, whereas in 1984 it was 2.51 t ha^{-1}, an increase of 45%. This coincides with the increase in N application to rice between 1981 and 1984. Table 1 summarizes the rice yield performance of the major improved and local varieties in 1981 and 1984. Therefore, it seems clear that the adoption of improved rice varieties combined with increased N application has substantially increased rice yields in this zone.

Land Use

The results drawn from the initial 1977 reconnaissance survey indicated that approximately 50% of the cultivated land in Sukchaina was planted to a rice monocrop (rice-fallow-fallow cropping pattern). In the parcel survey conducted in 1981, the area under rice-fallow-fallow had dropped to 45%. In 1984, after the influence of the extension effort by the Cropping Systems Program beginning in 1981, the area planted to rice-fallow-fallow in the surveyed parcels was only 2%. Farmers shifted from rice-fallow-fallow to other more intensive patterns such as rice-mixed crops-fallow, with lentil, mustard, and linseed being the major component crops in the mixed crops situation, rice-mustard-fallow and, most extensively, to rice-chickpea+mustard-fallow. Table 2 summarizes the cropping patterns used by farmers in the surveyed parcels in 1981 and 1984.

Figure 1 presents the average Land Utilization Indices and Multiple Cropping indices determined from the surveys in 1977, 1981, and 1984. Definitions of LUI and MCI and their calculations are presented in a footnote to Table 2. The figure clearly shows the extensive changes in land use that have occurred, particularly the intensification from 1981 onwards.

Much of the increase in cropping intensity has resulted from the adoption of improved, early maturing rice varieties. This has allowed farmers to spread out the peak work periods, particularly associated with rice harvest and land preparation for winter crops. More importantly, the early maturing improved varieties like Bindeshwari, Malika, CH-45, and IR 8423 can be harvested early, allowing timely land preparation for winter crops such as wheat, lentil, mustard, and chickpea. This has allowed a more effective use of the residual soil moisture after the monsoon rains and has indirectly increased yields of the winter crops in addition to the improved cultural and varietal practices that have been developed for the winter crops by the Cropping Systems Research Program.

The rice-chickpea+mustard-fallow pattern has been a major research contribution in Sukchaina. The identification of a new chickpea variety, GO-332, high yielding and adapted to local conditions, combined with timely planting in late October to early November after early maturing rice

varieties like Bindeshwari, has shown dramatic economic increases for farmers in Sukchaina. The obvious results that farmers observed in the rice-chickpea-fallow cropping pattern trials from 1981 to 1983 was transferred into adoption in their fields with the further improvement that farmers themselves made by including mustard mix cropped with the chickpea. Twenty of the surveyed parcels in 1984 were planted to the rice-chickpea+mustard pattern, whereas no parcels were planted to this pattern in 1981.

Table 3 presents a summary of the economic performances of the improved versions of the cropping patterns rice-wheat-fallow and rice-chickpea-fallow. Although both improved patterns (averaged over three years) are considerably better than the farmer practice of rice-wheat-fallow, economic benefits of rice-chickpea are outstanding. This illustrates why there has been a rapid adoption of the improved crop production technologies in Sukchaina as a result of the Cropping Systems Program activities.

CONCLUSIONS

From the basic principles of Nepal's seventh Five Year Plan (1985-1990): "In the present state of our country, to impart dynamism to the agriculture sector is a matter of paramount importance, if we really mean to increase our productive need of the people." Furthermore, His Majesty the King Birendra Bir Bikram Shah Deo has stated, "Let us note that any plan of development directed to raise the living standards of the people can be brought to fruition only with the active participation of the people themselves."

The changes that have occurred in increased crop production and improved economic returns at Sukchaina Village since the Cropping Systems Program was initiated in 1977 are a clear example of how the above directives can be successfully implemented. It has been the result of hard-working scientists, together with interested and cooperative farmers within the framework of a well defined research and extension methodology. The Cropping Systems Approach demonstrates the need for understanding the farmers' existing conditions, resources, and requirements, and provides opportunities to design relevant improvements based on available improved technologies. It means that the scientist must begin to think as a farmer and the farmer must begin to understand that science has something to offer. Together, as a team, scientists and farmers can develop sound, purpose specific field level research to develop solutions to improve crop production.

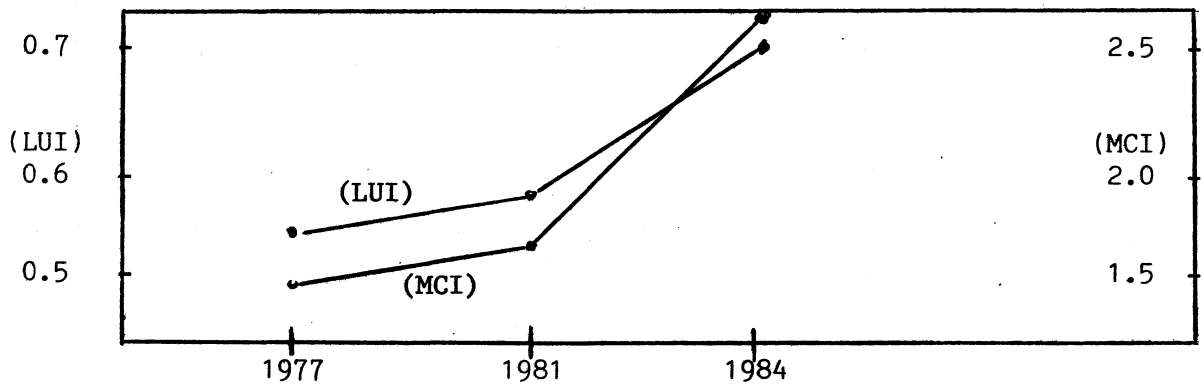
It is difficult to measure the economic contribution of the Cropping Systems Program at Sukchaina. The value of food available to those who did not have enough is priceless. Sukchaina has changed and is a better place for its villagers to live today than it was in 1977. The striking realization is that these changes have occurred in a rainfed environment that many in Nepal rule out as having potential for major production increases. This has clearly been shown to be wrong. There are hundreds of

other rainfed Terai villages in Nepal that can benefit from what has been learned and put into practice at Sukchaina.

Footnote

[1] For a thorough presentation of the research methodologies that have been followed, the reader is directed to the International Rice Research Institute (IRRI) publication entitled, "A Methodology for On-Farm Cropping Systems Research", by H. G. Zandstra, et. al.

Figure 1



CHANGE IN LAND UTILIZATION INDEX (LUI) AND MULTIPLE CROPPING INDEX (MCI), SUKCHAINA

Table 1

Rice Yield Performance (T/HA) of Different Varieties at Sukchaina from Parcel Surveys in 1981 and 1984.

Variety	1981	1984	% Increase Over 1981	% Increase Over Local Var. of '81
CH-45	1.67 (0.62)*	2.15 (0.60)	+28.7	+46.2
Bindeshwari	2.09 (0.57)	2.99 (0.37)	+43.1	+79.0
Masuli	1.65 (0.49)	2.16 (0.50)	+30.1	+29.3
Handiful	1.51 (0.55)	1.20 (0.00)	-20.6	-28.2
Other (Local)	1.42 (0.50)	1.50 (.042)	+ 5.6	-10.2

* Numbers in parentheses are Standard Deviations.

Table 2

Cropping Patterns, Land Utilization Index (LUI) and Multiple Cropping Index (MCI) in Surveyed Parcels at Sukchaina in 1981 and 1984.

Cropping Pattern	No. of Parcel		LUI		MCI	
	1981	1984	1981	1984	1981	1984
Rice-Wheat	52	60	0.71	0.71	2.0	2.0
Rice-Fallow	49	3	0.34	0.34	1.0	1.0
Rice-Mixed Crop*	5	22	0.70	0.60	4.0	4.0
Rice-Barley	4	0	0.70	0	2.0	2.0
Rice-Chickpea+Mustard	0	20	0	0.73	0	3.0
Rice-Mustard	0	4	0	0.61	2.0	2.0
Rice-Lentil	8	7	0.69	0.69	2.0	2.0
Rice/Lathyrus	4	5	0.73	0.73	2.0	2.0
Weighted $\overline{X}$	122	121	0.56	0.70	1.68	2.53

* Mixed Crop involves varying combinations of Mustard, Lentil, Linseed, Broadbean, and Peas. Average of 3 crops in the mixed crop situation has been used to calculate MCI.

Land Utilization Index - The number of days during which crops occupy the land during a year, divided by 365.

Multiple Cropping Index - The sum of the areas planted to different crops harvested during the year, divided by the total cultivated areas.

Table 3

Economic Performance of Different Improved Cropping Pattern at Sukchaina.

($\overline{X}$= 1982-1984)

Cropping Pattern	Total Annual Yield (t/ha)	Gross Returns (Rs/ha)	Total Variable* Cost (Rs/ha)	MBCR#
A. IMPROVED PRACTICE				
Rice-Chickpea-Fallow	4.57	15,012	5,249	9.27(1.57)§
Rice-Wheat-Fallow	4.40	11,558	5,977	2.43(0.30)
B. FARMER'S PRACTICE				
Rice-Wheat-Fallow	3.12	8,940	4,642	- ¶

* Total variable costs include input costs and labor and power costs.

MBCR = Marginal Benefit Cost Ratio. This is calculated by dividing the difference in the Gross Returns of the Improved Practice minus the Gross Returns of the Predominant Local Farmer's Practice by the difference in the Total Variable Costs of the Improved Cropping Pattern minus the Total Variable Costs of the Predominant Local Farmer Practices.

§ Numbers in the parentheses are Standard Deviations.

¶ Farmer Practice used to calculate the MBCRs of the Improved Practices.

ON-FARM TRIALS CONDUCTED AT FARHATABAD VILLAGE, CENTRAL INDIA FOR TESTING OF AN IMPROVED VERTISOL MANAGEMENT TECHNOLOGY

R. T. Hardiman

BACKGROUND

In India, 73 million ha of land are overlain by vertisols, of which 43 million ha is in the assured rainfall zone. Much of this land is lain fallow during the rainy season due to inherent properties of the soil that cause it to be unmanageable when wet and prone to waterlogging. As a consequence, farmers depend upon stored soil moisture during the postrainy season with which to grow their crops (ICRISAT, 1984). An improved vertisol management technology (IVMT) was developed to enable proper drainage of the soil during the rainy season and growth of two crops per year instead of one. The watershed-based technology employs a graded, raised, broadbed, and furrow tillage configuration intersected by grassed waterways in order to optimize infiltration and carry excess rainwater from the field to community drains. Supplement to this, secondary components were introduced:

- Use of a bullock-drawn wheeled tool carrier (WTC) to carry out tillage and sowing operations;
- Sowing prior to onset of the monsoon while the soil is still manageable;
- Improved intercropping and double cropping systems suitable to the prevailing rainfall pattern;
- Improved plant protection methods, and
- Use of high yielding and disease resistant crop varieties.

The technology was developed and tested at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India since 1976 (Kampen, 1980). It proved successful, providing profits approximately 250% above those of traditional farming methods (ICRISAT, 1984). In 1982, the technology was tested under on-farm conditions at various locations in India. In this report, we intend to summarize our experience and results for a 3-year study at Farhatabad village, conducted in collaboration with the Department of Agriculture, Karnataka. The project area was 16.4 ha involving 2 farmers in 1982, expanding to 20.4 ha and 3 farmers in 1983, and 40 ha and 4 farmers in 1984.

Description of the Site

Farhatabad (17.25 N, 76.52 E) is 18 km south of Gulbarga, Kanataka, India and has a population of 3018. The total cultivable land area is 1750 ha, of which 60% is fallowed during the rainy season. There are 391 farmers owning average landholding of 4.5 ha. Facilities in Farhatabad are minimal but the town of Gulbarga has most agricultural materials available. Annual average

rainfall is 727.4 mm, having a bimodal pattern commencing mid-June and ending early October. Approximately 80% of the total annual rainfall occurs during this period. The maximum and minimum temperatures are 40.3°C and 14.3°C respectively, and mean pan evaporation rate is 5 to 6 mm d^{-1} from 15 July-28 January, encompassing most of the growing season.

The watershed area covers 173 ha of land, of which 40 ha are within the project area (Figure 1). The topography is gently sloping, undulating terrain; mean slope is 1 to 2% in a westerly direction. The soils are medium to deep black soils, classified as Chromustert or Typic Chromusterts. They are friable when dry, do not form deep cracks, and tillage is relatively easy. Soil chemical and mechanical analysis (Tables 1 and 1a) indicate high clay content (66%) and relatively low nitrogen and phosphorus status: data were collected after the cropping season (May).

Current Farm Practices and Constraints

Farhatabad area is primarily a pigeonpea and postrainy season sorghum tract, where pigeonpea provides the main source of income while sorghum constitutes the staple food source and fodder for cattle. A typical farmer would maintain a two year rotation for these two crops and therefore the land would be fallowed during the rainy season once every two years. Cultivation is carried out by a bullock-drawn wooden plow or harrow and sowing and fertilization by a wooden seed drill; all other operations are manual. "Traditional" farmers are relatively advanced and fertilizer and pesticide use is common practice.

Pigeonpea is subject to severe attack from the *Heliothis armigera* larvae (pod borer), causing grain yield losses of up to 60%. Current practices of control are to use a foot pump insecticide sprayer loaded onto a bullock cart which then proceeds through the pigeonpea crop. This method requires 3 to 4 laborers and 500 liters of water per ha at a time when water availability is limited. The bullock cart damages the crop, flowers, and buds, and spraying effectiveness is limited. In a second method, an insecticide dust is applied manually; distribution is poor and the laborer, who normally does not wear a face mask, is subject to a severe health hazard. In both methods, time of application is determined by visual observation of the *Heliothis* larvae, by which time the major damage has occurred.

Wilt (*Fusarium oxysporum f. sp. udum*) occurrence in pigeonpea is serious, particularly in poorly drained or waterlogged areas. Moreover, the high profits obtained from pigeonpea is resulting in continuous cropping of pigeonpea, without rotation. This, in turn, is leading to a build-up of wilt in some fields. Both *Heliothis* attack and wilt is causing substantial yield reduction of pigeonpea, and thus typical grain yields are only 700-1000 kg ha^{-1}.

Sorghum is sown in late September. Average grain yields are 500 to 700 kg ha^{-1}, and grain prices are stable at Rs. 1800 10^{-3} kg. The fodder is also of substantial importance, yielding about 2000 to 3000 kg ha^{-1} and can fetch Rs. 300 10^{-3} kg. The period between the onset of the monsoon and

sowing of sorghum is only 100 to 120 days. A short duration crop, such as mungbean, is sometimes grown during this period, but profits are low. The land is therefore normally fallowed during the rainy season and harrowed 2 to 3 times to eradicate weeds in preparation for sorghum planting.

Other crops include groundnut, safflower, sesamum, and sunflower grown in small areas. Sesamum is grown for personal use of the farmer.

The semi-assured nature of rainfall pattern at Farhatabad creates problems of both waterlogging and drought stress to crops. A need was therefore apparent to control and optimize moisture regimes to suit the erratic nature of the rainfall.

In brief, the major constraints to production at Farhatabad are: (1) *Heliothis armigera* attack and wilt infection in pigeonpea; (2) erratic rainfall and, therefore, both drought stress and waterlogging; (3) unproductive land during the fallow period every 2nd year, and (4) low income from the mungbean crop grown during the rainy season.

METHODOLOGY

In light of the constraints itemized above, IVMT was adapted in an attempt to solve some of the priority problems evident at Farhatabad.

1. Use of the WTC fitted with a 3-headed, ultra-low volume (ULV) sprayer for spraying operations.

2. Implementation of timely application of pesticide to control *Heliothis* attack on pigeonpea.

3. Introduction of wilt resistant varieties of pigeonpea (ICPI6 and ICP8863).

4. Introduction of extra early and early maturing pigeonpea varieties (ICPL4 and ICPL87 respectively) suitable for rainy season fallowed land and as a substitute for low income mungbean in a sequential cropping system.

5. Trials with sesamum, groundnut, and pearl millet intercropped with pigeonpea.

The farmers voluntarily came forward to participate in the study; no incentives were given other than some seed varieties we wished to test or loan of improved farm implements. Scientific staff and the department of agriculture initially surveyed the watershed area and designed the broadbed and furrow and waterway layout (Figure 1). The broadbeds were then maintained by the farmers on their initiative. No loans or funds were provided to carry out necessary land smoothing and field drainage operations; these operations were therefore minimized. Cultivation and sowing were carried out by the WTC in most instances. A field technician was permanently on location to ensure smooth running of field operations and

to provide advice when necessary. Farmers had a free hand to select their own cropping systems and inputs, although advice was given regarding new varieties, potential cropping systems, and plant protection needs. Cooperation was generally good. Data were collected both from project farmers and "traditional" farmers' fields in the watershed area.

Each cropping system tested in the watershed was analyzed plot-wise. Data were recorded for time expenditures for operations, all material inputs, implements used in carrying out field operations, and labor and bullocks employed. Yields were calculated from plot subsamples (8 samples ha^{-1}) collected from 10 m^2 areas. Economic evaluation was based upon actual material and labor costs and bullock rental cost. Family labor and owned bullocks were considered the same as hired labor and bullocks. The WTC and other hired machinery were charged according to fiscal rates. Gross returns were calculated from local market prices of produce approximately 1 month after harvest.

Where possible, data were also collected from traditionally maintained fields within the watershed that had similar cropping systems to those tested under IVMT. The area sampled in the traditional cropping system was equal to or greater than that within the project area. Often, a cropping system in an IVMT field was not represented in traditional fields.

Difficulties in selecting traditional fields should be realized. Fields of each cropping system expressed variable yields and are subject to variable inputs, cropping histories, and farm management. Efforts were made to select fields that were within the medium range of "the norm" of farm practices. Even so, factors such as time of spraying pigeonpea were critical in determining final yield and profit values. Similarly, IVMT fields for a particular cropping system were not uniform in material inputs or farm management practices.

RESULTS AND DISCUSSION

Rainfall at Farhatabad, 1984-85, and Effect on Cropping System

The rainy season of 1984 represented a year of severe drought in many parts of Karnataka. Total rains received in Farhatabad were 539 mm in contrast to the mean annual rainfall of 727 mm. Moreover, the onset of the monsoons commenced one month later than expected, on 12 July, which led to the curtailment of certain cropping systems. The rainfall maintained a distinct bimodal pattern. The southwest monsoon precipitated 315 mm between 12 July-9 August, followed by a complete dry spell for one month until 11 September, initiating the onset of the northeast monsoon continuing until 12 October and precipitating 209 mm. This rainfall pattern had a substantial effect on the cropping systems employed by farmers, and the decision-making process for crops was in a continual state of flux during the month of June. The initial intentions for a sorghum/pigeonpea intercrop were curtailed due to probable shootfly problems and pearl millet/pigeonpea intercrop was taken up instead. Mungbean, although planted, had predictably low yields (87 kg ha^{-1}) due to late sowing, excessive vegetative growth, and little pod

formation. Groundnut was only taken up on a small scale due to predicted drought conditions. Early maturing pigeonpea ICPL4 and ICPL87 was also tested only on a small scale since it was evident that its harvest would be too late to take up a second crop. Many farmers were confronted with the decision to fallow the land and prepare it for a postrainy season sorghum crop and therefore receive only moderate returns, or to take up a pigeonpea crop for a second successive year. This would generate greater profits than sorghum, but there would be risk of wilt infestation to the crop and possibly increased wilt sickness in their fields that would affect future pigeonpea crops. In the outcome, farmers decided to compromise the situation and take up both options.

Dry Sowing

Rainfall probability data (Virmani, et al., 1982) was used to discern a suitable date for dry sowing. The rainfall pattern at Farhatabad has dual tendencies. If rains do occur during the 24th standard week (17-23 June), then there is a 65 to 83% probability that they will continue until the 30th week (22-28 July) (W/W curve, Figure 2). If, however, rains do not arrive by 17 June, then the probability of rains occurring decreases from 63 to 45% over the succeeding 5 weeks (W/D curve, Figure 2). With such dualistic patterns, no date for dry sowing can be given. Rather, the farmer can be advised to wait for accumulative rains of at least 30 mm before sowing. If rain does not occur by 8 July, then dry sowing can commence with 80% confidence that rains will occur during the 28th week (9-15 July).

In 1984, dry sowing prior to the predicted date of onset of monsoons was not carried out, which was fortunate in lieu of late arrival of the rains. Wet sowing was, however, problematic. Continuous rains during the latter half of July prevented farmers from entering the field and this further postponed the date of sowing. One field (Survey No. 75) was dry sown with mungbean on 6 July, 6 days before the onset of rains, and germination was excellent.

Cropping Systems Evaluation

The final cropping system that evolved is shown in Figure 3. Results of material inputs and yields for each cropping system are given in Table 2. Of the 40 ha area within the project, 52% was cropped with sole pigeonpea, 25% fallow rainy season + postrainy season sorghum, 14% mungbean + sequential safflower, 4% pigeonpea intercrop, and the remainder was sole groundnut and early maturing pigeonpea trials.

Sole Pigeonpea. Pigeonpea yields in IVMT fields were 70 to 120 kg ha^{-1} higher than in previous years. Moreover, mean yields of IVMT fields (1417 kg ha^{-1}) were 25% higher than those of traditional fields (1134 kg ha^{-1}). The difference is largely attributed to good *Heliothis* control and higher fertilizer inputs. Notable were fields that were sprayed by the WTC mounted ULV sprayer and, according to ICRISAT advice, showed only 5.1% pod damage, whereas the two fields sampled that were sprayed by local methods without ICRISAT advice showed 11.3% pod damage. Similarly, a mean of 94 kg DAP (Diammonium phosphate) ha^{-1} was applied to IVMT sole pigeonpea fields,

compared with 65 kg DAP ha^{-1} in traditionally managed fields.

Wilt was not a severe problem this year; a prolonged dry spell and bimodal distribution of rains left the fields well drained for the most part of the growing season and therefore less subject to wilt. However, wilt resistant varieties, ICPI6 and ICP8863, which were tested alongside other varieties performed well. ICP8863 grown outside the project area yielded 1500 kg ha^{-1} and no wilt was detected. ICPI6 also gave comparable mean yields of 1560 ± 314 kg ha^{-1}. In a wilt susceptible plot ICPI6 gave 1740 ± 445 kg ha^{-1} and wilt infection was estimated at 5 to 10% of the plant population compared with a local variety (GS-1) which gave 1414 ± 480 kg ha^{-1}, and wilt was estimated at 25%. Farmers, however, noted that ICPI6 matured about 14 days later than other varieties (BDN-1, GS-1, PT221), at which time the market price of pigeonpea was lower.

Fallow rainy season + postrainy season sorghum. Late onset of the monsoon was largely responsible for the fallowed land in the project area. Similarly, poor moisture conditions caused most farmers to enact a minimal input policy for the postrainy season sorghum crop. Thus, fertilizer input was zero in both IVMT and traditional fields, with the exception of one plot. This was probably advantageous under the prevailing moisture conditions since it reduced vegetative growth and preserved some soil moisture for grain formation. The combined effect of low nutrient status and drought stress generated low sorghum yields. However, in IVMT fields, a mean sorghum yield of 776 kg ha^{-1} was attained compared to 442 kg ha^{-1} in traditional plots. The reason for the difference is unclear and is tentatively attributed to better crop stand and crop management.

Mungbean + postrainy season sorghum. Dry sown mungbean germinated well; however, late sowing (6 July) resulted in excessive vegetative growth and poor pod development. Yields in both IVMT and traditional plots were low (87 kg ha^{-1} and 82 kg ha^{-1} respectively). Postrainy season sorghum yielded well in IVMT plots (1050 kg ha^{-1}) compared to traditional plots (491 kg ha^{-1}). The difference may be due to application of FYM in the traditional plots which could have reduced the availability of soil nitrogen during initial stages of nitrification.

Sole groundnut and groundnut + sequential safflower. Attempts to follow groundnut with safflower failed. Duration of the local groundnut variety and Robut 33-1 was 103 and 115 days respectively, thus harvest took place after the last rains. As a consequence, there was severe moisture depletion in soil surface horizons and safflower seed failed to germinate.

Both local groundnut varieties and Robut 33-1 yielded well, considering the prevailing moisture conditions, and provided 1311 kg ha^{-1} and 1480 kg ha^{-1} respectively.

Intercropping

Intercropping with pigeonpea was carried out in a small area (1.57 ha) covering 4% of the project area and was mainly for short duration pulse crops: mungbean, sesamum, and groundnut. Although a 1:4 pigeonpea/pulse

ratio was advised on the basis of ICRISAT research results, farmers maintained a 2:2 ratio in order not to reduce their pigeonpea yield too severely. This decision was founded on former results: in 1982 and 1983 a 1:4 pigeonpea/groundnut intercrop generated only 177 kg ha^{-1} of groundnut due to adverse, wet conditions, whereas pigeonpea maintained an expected 75% of the sole crop yield (ICRISAT, 1984). In 1984, soil conditions were drier and a 2:2 ratio provided 536 kg ha^{-1} of groundnut and 85% of pigeonpea sole crop yield. The results would suggest that the rainy season intercrop is severely affected by the prevailing rainfall, whereas pigeonpea is more stable against erratic climatic conditions. Thus, although economic returns may be potentially greater in a 1:4 system, the risk of reduced income from groundnut loss is also greater and a 2:2 system is better advised.

On a similar basis, pigeonpea yields were also substantially decreased in the 1:4 pigeonpea/sesamum cropping system. In 1982, a 1:4 ratio generated a 25% decrease in sole crop pigeonpea and only 160 kg ha^{-1} of sesamum; in 1983 and 1984, a 2:2 ratio generated 175 ± 106 kg ha^{-1} of sesamum, and pigeonpea yields were 14 to 22% higher than sole crop yields. The reason for enhanced pigeonpea yield is not known; however, the results substantiate field experiments which show that sesamum competitiveness with pigeonpea can be reduced by reducing the cropping ratio (M. S. Reddy, ICRISAT, personal communication).

Pigeonpea/pearl millet. This was planted in 1:2 ratio using ICPI6 and WCC75 varieties. Yields were moderate, 871 kg ha^{-1} and 983 kg ha^{-1} for pearl millet and pigeonpea respectively; however, returns were low (Rs. 2994 ha^{-1}). The cropping system was not favored by the farmers due to (1) reduced pigeonpea yield and (2) no market for pearl millet. The WCC75 variety was noted for its high yielding capacity and good fodder value, but considered too competitive with pigeonpea to be suitable as an intercrop.

Economic Evaluation of Cropping Systems

The economic evaluation of cropping systems is given for each cropping system in Table 2. Highest gross profits under IVMT were achieved from pigeonpea/sesamum intercrop (Rs. 5330 ha^{-1}) seconded by pigeonpea/groundnut intercrop (Rs. 5178 ha^{-1}). Moderate profits were attained from sole pigeonpea (Rs. 3869 ha^{-1}) and lowest profits from fallow + postrainy season sorghum (Rs. 1289 ha^{-1}).

The yield and profits attained this year were a result of the prevailing rainfall pattern and do not wholly reflect the "norm" for Farhatabad. The rank ordering of profits is the inverse of the proportionate area grown under each cropping system and would indicate alternative reasons for maintaining low to moderately profitable cropping systems.

Suggested reasons are as follows: high risk in dryland farming does not warrant investment of higher input costs; thus, in evaluating cropping systems, cost input is an important factor. Total operation costs for various cropping is given in Table 3. For fallow + sorghum and sole pigeonpea, it is Rs. 756 ± 85 ha^{-1} and Rs. 1214 ± 78 ha^{-1} respectively. For

all other cropping systems, the operation costs are at least Rs. 240 ha^{-1} to Rs. 1000 ha^{-1} higher. Even by introducing mungbean to replace the rainy season fallow, an additional Rs. 600 to 800 ha^{-1} is required and, as seen from this year's results, the risk of financial loss is considerable (Table 2). It is therefore not surprising that although better returns can be attained from alternative cropping systems, the more traditional systems are favored.

Pigeonpea/sesamum (2:2) intercrop shows potential, both in profit and moderate input costs, compared to traditional systems. Highest profits of all trials were achieved from this cropping system, both in 1983 and 1984, providing Rs. 7916 ha^{-1} and Rs. 5330 ha^{-1} respectively. Operation costs were Rs. 1509 ± 27 ha^{-1}, approximately Rs. 240 ha^{-1} higher than for sole pigeonpea. Pigeonpea/groundnut (2:2) also shows promise; however, operation costs are high (Rs. 2331 ha^{-1}), partly due to high seed and harvest costs. This system also presents a high risk since groundnut crop failure is likely under adverse, wet climatic conditions, as noted in 1982 and 1983. For these reasons, groundnut is only grown on a small scale.

Other Crop Experiments

Early maturing pigeonpea. Trials were conducted to assess the suitability of early maturing pigeonpea varieties as a rainy season crop that could fit into sequential cropping systems involving postrainy season sorghum or safflower. If successful, this could replace the low income mungbean and fallowed land, thus encouraging rainy season cropping.

Early maturing pigeonpea varieties ICPL4 and ICPL87 have a nominal duration of 90 days and 120 days respectively and therefore could ostensibly be used as rainy season crops. Unfortunately, the erratic nature of the rainfall pattern often leads to late onset of monsoons or its early recession. Thus, decision-making processes regarding this crop will be very dependent upon the rainfall pattern of a particular year and the risk involved if the rains should recede early such that subsequent planting of a postrainy season crop is curtailed. This year, yield of ICPL4 (593 kg ha^{-1}) was good, considering the probable moisture stress imposed on the crop (Table 4). Gross returns are comparable with those obtainable from mungbean, and as an early season pigeonpea, could fetch higher prices than normal.

The ICPL87 variety matures too late to plant a subsequent crop after its harvest, but has a compensatory mechanism in that it may be ratooned and a second crop can produce substantial yields (Chauhan, 1984). The option to ratoon is, however, dependent upon available soil moisture, and if rains are poor, this may not be worthwhile.

At a local seed farm, ICPL87 was grown on 1.62 ha, of which certain areas were selected for economic evaluation of harvest methodology. Three methods were employed: full harvesting of the crop, ratooning by cutting the heads of the plant, and ratooning by hand picking. Crop stand was quite variable within the field due to poor moisture conditions and soil depth. Thus, only the better crop areas were selected for evaluation of these

treatments.

It can be seen from Table 5 that harvesting of the ratooned crop is 5 to 10 times more costly than by fully harvesting the crop. Moreover, threshing is also more costly for hand picked pods. The adoptability of ICPL87 as a ratoonable crop, therefore, seems to be limited due to economic reasons, and it would only be suitable in areas where labor costs are low.

Pod Borer (*Heliothis armigera*) Control

Timeliness of spraying. The purpose of these trials was to investigate the advantage of timely applied pesticide to combat *Heliothis a.* as compared to the local "visual" assessment method. The method introduced by ICRISAT involves continuously monitoring *Heliothis a.* infestation of crop at flowering and budding stages. Spraying is advised at the economic threshold when there are an average of 10 to 12 eggs/plant or 2 to 3 small larvae/plant (Pawar, 1983). In 1983, trials were conducted to compare this method with conventional methods. Three fields were selected for this purpose.

- High intensity spraying by the local method (7 times/season);
- Spraying by the local method at moderate intensity (4 times/season), and
- Spraying according to economic threshold determined by *Heliothis a.* monitoring (2 times/season).

Results (Table 6) show that although highest yields were attained in the high intensity sprayed plot, expenditure in spraying was 4 times that of the improved method; thus, effective profits were Rs. 391 ha^{-1} higher by the latter method. Conversely, in the moderate intensity local method, expenditure was less but yields were low. Pod damage data indicate that *Heliothis a.* control was best under the improved method; the data do not, however, wholly explain the variable yield differences and other factors must be assumed.

Tentatively, it can be concluded that benefits of spraying by the improved approach are marginal when compared with intensive spraying. The method, although more ecologically sound, requires farmers or personnel to be well-trained and precise in determining the correct time of spraying. Experimental data are still required to determine the distinct advantages of timely application of pesticide when compared to high intensity spraying.

Method of spraying. In 1982, ICRISAT introduced the ultra-low volume (ULV) sprayer to Farhatabad farmers. The implement is cheap (Rs. 500), reliable, and requires only 8 to 10 liters of water per ha. The sprayer was rapidly adopted by Farhatabad farmers, and in 1984 the total number of ULV sprayers purchased in the village was approximately 100.

In 1984, a WTC mounted with a 3-headed ULV sprayer (WTC/ULV) was introduced to the project farmers. The unit had the same advantages as the

ULV sprayer and could be raised above the pigeonpea crop and pass through the field without causing damage. The 3-headed boon had a span of 7.5 m and could cover 1 ha in 1 hour with the use of one laborer. The relative advantages compared to other methods are listed in Table 7. Both ULV and WTC/ULV have shown a saving of Rs. 45 to 122 ha^{-1} spraying above conventional methods. The WTC/ULV has a potential working capacity of 40 ha during peak spraying season, assuming 5 days maximum possible delay in spraying. Thus, if 3 sprays are applied per season, the WTC/ULV can save Rs. 5400 to 14640 $season^{-1}$ 40 ha^{-1}. Moreover, combination of the WTC/ULV sprayer with the improved approach to timeliness of spraying has resulted in pod damage of only 5.1 ± 1.3% after three sprayings. An indication of the success of the unit was demonstrated by one farmer who built his own unit based on the ICRISAT design two weeks after introduction of the WTC/ULV to Farhatabad. Farmers also indicate that it is advantageous because the laborer can work without supervision.

CONCLUSIONS

It is clear from the above analysis that although the "upstream" approach defined by Gilbert, et al., (1980) can provide a basic technology for large areas, under specific agroclimatic regions, the technology must undergo severe change in order to adapt to the conditions imposed. Dry sowing of seeds prior to the onset of monsoons is inappropriate in the Farhatabad area. The broadbed and furrow system can, in the farmers' opinion, provide a more controlled moisture environment to the soil during the rainy season. However, the economic benefits are uncertain and funds for cost of land smoothing and field drainage must be found.

Priority need in Farhatabad area is proper *Heliothis a.* control. The method of timely application of pesticide through monitoring of *Heliothis a.* population is recognized by farmers; however, they feel incompetent to carry out population monitoring and to decide time of spraying. Trained personnel should be present, or farmers should undergo training themselves.

Results also indicate that clear economic advantages can be achieved by intercropping when compared to traditional systems. However, it appears that farmers are reluctant to take up extensive intercropping due to higher input costs and the high risk of failure of the rainy season intercrop. In a semi-assured rainfall zone such as Farhatabad, low input crops such as sorghum and pigeonpea, which are relatively stable under adverse conditions, are preferred. For similar reasons, farmers did not intercrop in the ratio that would potentially provide maximum economic returns and preferred the ratio that would provide more stable returns under varying rainfall conditions. Thus, the 2:2 ratio for groundnut or sesamum:pigeonpea intercrop was preferred to the 4:1 ratio.

Over three years, IVMT expressed an average of 45% increase in gross profits above the traditional system for green gram + sequential sorghum and sole pigeonpea cropping systems, while fallow + sorghum sequence showed a 31% increase. The reason for the increase is variable and confounding. In general, the IVMT plots were managed better and more care was taken to

ensure good crop yield. The WTC provided good tilth and visual evidence showed that sowing using the WTC mechanical planter led to better intra and inter row spacing and better crop stand. Fertilizer inputs were generally higher than in traditional crops, but this was not consistently so.

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Table 1: Soil Chemical Analysis - Farhatabad Watershed

Depth cm	pH*	E.C* $S.m^{-1}$	Organic Carbon %	P $mg.kg^{-1}$	$N\text{-}NO_3$ $mg.kg^{-1}$
0-30	8.1 ±0.1	0.022 ±0.004	1.72 ±0.6	1.4 ±0.8	6.5 ±1.6
30-60	8.1 ±0.1	0.013 ±0.002	0.44 ±0.1	<0.5 ±0.0	4.3 ±0.8
60-90	8.1 ±0.1	0.016 ±0.003	0.43 ±0.1	0.75 ±0.6	4.3 ±1.4
90-120	8.1 ±0.0	0.030 ±0.014	0.38 ±0.0	0.7 ±0.4	6.1 ±4.9

* Values given for soil solution extract 1:2, soil:water ratio

Table 1a : Soil Mechanical Analysis - Farhatabad, Karnataka

	CEC $\frac{1}{2}$ mmol(+).kg^{-1}	Mechanical Composition (%) Clay	Silt	Fine sand	Coarse sand	Gravel
Soil depth (10 cm)	570	66	28	1	1	4

Table 2: Survey of economic components and yields for different cropping system at Farhatabad 1984-85

Technology	Cropping system/ No. of plots	Area (ha)	% of total project Area	Material cost Rs.ha^{-1}	Bullock or labour cost Rs.ha^{-1}	WTC and other Rs.ha^{-1}	Total cost Rs.ha^{-1}	Yield kg.ha^{-1}	Gross returns Rs.ha^{-1}	Gross Profits Rs.ha^{-1}
				SOLE PIGEONPEA						
IVMT	Sole pigeonpea (6)	17.86	52	818	462	172	1452	1417	5321	3869
IVMT/FOG	" (1)	2.81		692	457	131	1280	1676	6232	4952
Traditional	" (14)	43.06	-	623	479	52	1154	1134	4324	3170
				SEQUENTIAL CROPS						
IVMT	GN+SF* (2)	0.27	<1	933	1043	77	2053	1140 O+(SF)	5600 O+(SF)	3547
IVMT + Local	GG+SF+ (1)	5.5	14	748	655	107	1510	87 (GG) 803 (SF)	436 (GG) 2891 (SF)	1817
IVMT + Local	GG+SO (1)	0.24	<1	456	1000	103	1559	87 (GG) 1050 (SO)	436 (GG) 2861 (SO)	1738
Trad.	GG+SO (1)	3.64	-	1328	990	157	2475	82 (GG) 491 (SO)	412 (GG) 1885 (SO)	178
				INTERCROP						
IVMT	PP/GN (1)	0.53	1	1173	1003	155	2331	536 (GN) 1340 (PP)	2534 (GN) 4975 (PP)	5178
IVMT	PP/SM (1)	0.34	<1	708	625	149	1482	100 (SM) 1611 (PP)	800 (SM) 6012 (PP)	5330
IVMT	PP/PM (1)	0.70	2	791	822	251	1864	871 (PM) 983 (PP)	1176 (PM) 3682 (PP)	2994
Trad.	PP/GG (1)	4.0	-	915	860	30	1805	150 (GG) 875 (PP)	750 (GG) 4000 (PP)	2945
				FALLOW + RABI CROP						
IVMT.	Fallow+SO (2)	10.04	25	0	554	205	790	776	2086	1296
Trad.	Fallow+SO (7)	31.24	-	35	697*	25	757	442	1270	513
Trad.	Fallow+SF (4)	6.7	-	201	600*	0	801	604	2177	1376

* Estimated cost

\+ Safflower failed due to poor germination and lack of soil moisture

GN groundnut, SF safflower, SO sorghum, GG greengram, PP pigeonpea, SM sesamum, PM pearl millet, IVMT improved Vertisol management technology, Trad: traditional farming, FOG: Flat-on-grade

Table 3: Summary of Economic evaluation of principal cropping systems in Farhatabad 1982-85

Technology	Cropping system	Gross Returns	Operation cost	Gross Profits	Years of data collected
		Rs/ha^{-1}			
IVMT	GG + SO	4450 ± 1630	1556 ± 2.5	2898 ± 1160	2
Trad.	"	3359 ± 1515	1365*	2994	2
IVMT	Sole PP	5697 ± 584	1269 ± 162	4427 ± 711	3
Trad.	"	3919 ± 997	1159 ± 7	3037 ± 1820	2
IVMT	Fallow + SO	2563 ± 675	736 ± 76	1827 ± 751	2
Trad.	"	2246 ± 1380	856 ± 141	1390 ± 1240	2
IVMT	GN/PP (4:1)	5002 ± 625	1727 ± 272	3275 ± 353	2
IVMT	GN/PP (2:2)	7509	2331	5178	1
IVMT	SM/PP (2:2)	8131 ± 1865	1509 ± 27	6623 ± 1828	2

* Operation cost for one year included.
IVMT = Improved Vertisol Management Technology
Trad = Traditional practices
GG = Greengram, SO = Sorghum, GN = Groundnut, PP = Pigeonpea, SM = Sesamum

Table 4 : **Early maturing pigeonpea varieties at Farhatabad Watershed**

Variety	Area (ha)	Date of emergence	Date of harvest	Duration (days)	Fertilizer $kg.ha^{-1}$	Yield $kg.ha^{-1}$
ICPL4	0.38	3.8.84	5.11.84	97	62DAP	593
ICPL87	0.21	10.7.84	28.12.84	158	61DAP	440
ICPL87	0.18	2.8.84	6.12.84	128	62DAP	860

Table 5 **Cost Effectiveness of harvest methodology of Early Maturing Pigeonpea (ICPL87) - Kotnur Seed Farm, Gulbarga**

Item (per ha)	Fully harvested crop	Ratoon cut	Ratoon hand picked crop
No. of manday	46	232	416
+labor cost (Rs.)	322	1624	2917
Yield (kg)	1079	1014	1222
*Gross returns (Rs.)	4100	3853	4644

+labor cost @ Rs.7.00/day (women labor)
*Based on market price Rs.3.80/kg

Table 6 : Economic evaluation of conventional approach and timely applied pesticide for <u>Heliothis</u> a. control

Method	Area (ha)	No. of sprays	% Pod damage	Total cost $Rs.ha^{-1}$	Yield $kg.ha^{-1}$	Gross Returns $Rs.ha^{-1}$	Gross - Returns	Spraying Cost $Rs.ha^{-1}$
Improved	6.04	2	6.6	364	1400	7000		6636
(i) Local method	6.15	7	8.3	1405	1530	7650		6245
(ii)Local method	2.0	4	9.7	622	563	2815		2193

Table 7 : Comparison of Pigeon Pea Spraying methodology Farhatabad 1984

Method	Water reqd. $L.ha^{-1}$	Man hrs/ ha^{-1}	Bullocks pair $hr.ha^{-1}$	Pesticide cost (Rs.)	labor+ Bullock $Rs.ha^{-1}$	Total Cost $Rs.ha^{-1}$	Coverage/ day (ha)
WTC/ULV	8-10	1	1	148.00	7.50	155.50	6-8
Local Cost/ foot pump	500	24	8	148.00	50.00	198.00	1
ULV(Manual)	8-10	4	0	148.00	5.00	153.00	2
Dusting	0	40	0	225.00	50.00	275.00	1

\+ Labor Cost Rs. 10.00 per day (8 hr.)
* Bullock Pair Rs. 20.00 per day (8 hr.)
\# WTC/ULV rental Rs.3.75/day

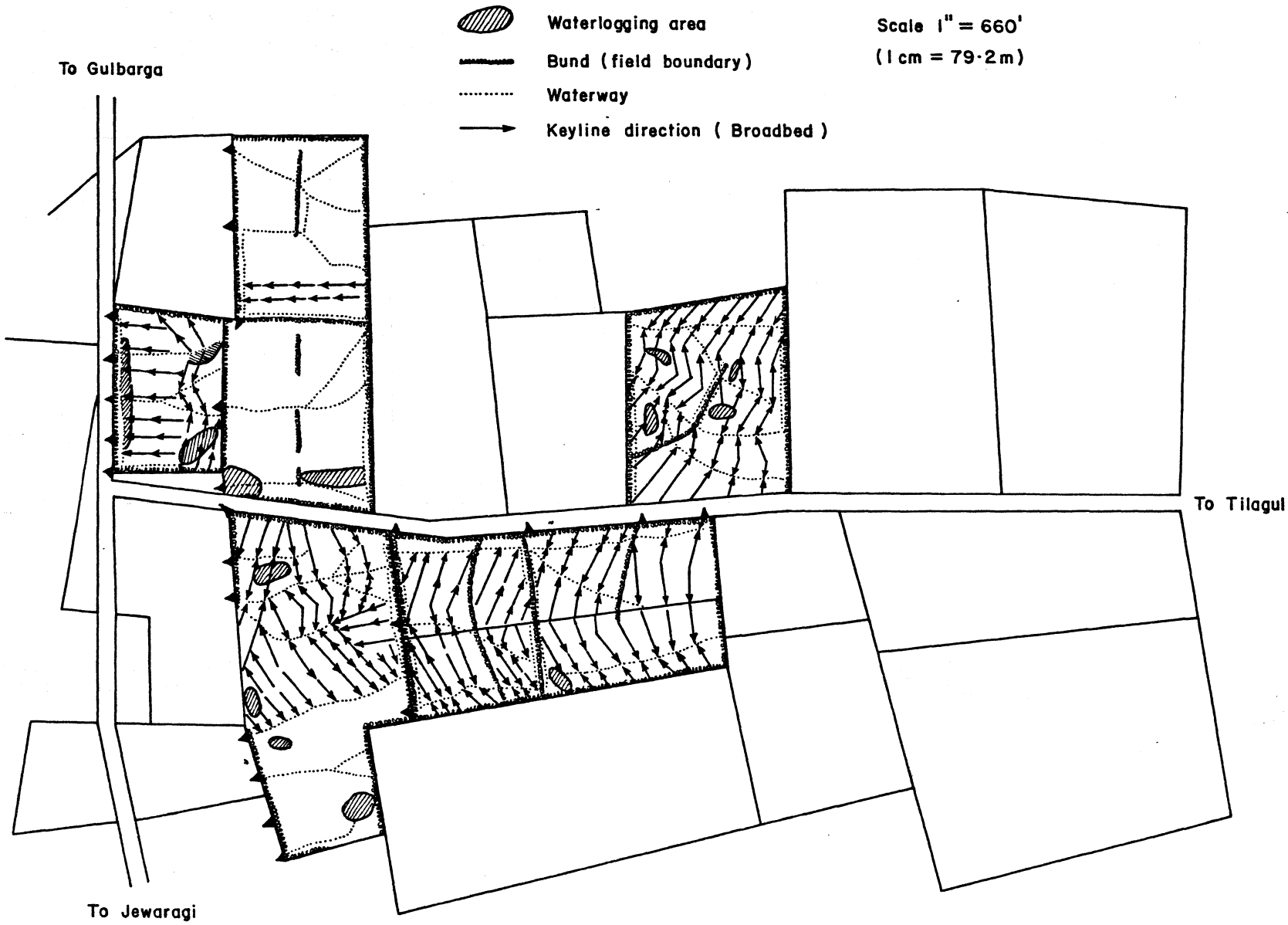


Fig. 1: Broadbed and furrow and waterway system Farhatabad 1984 – 85

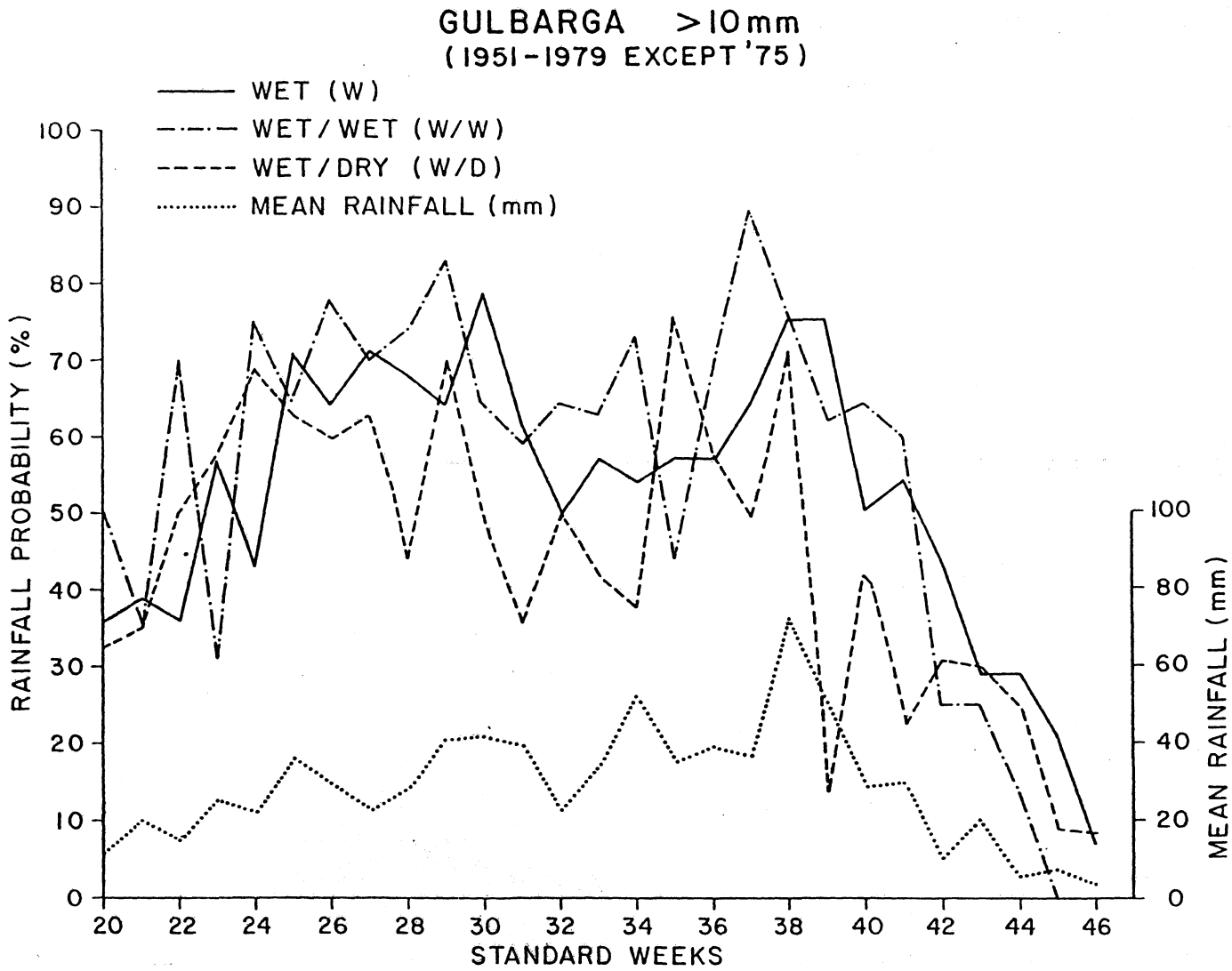
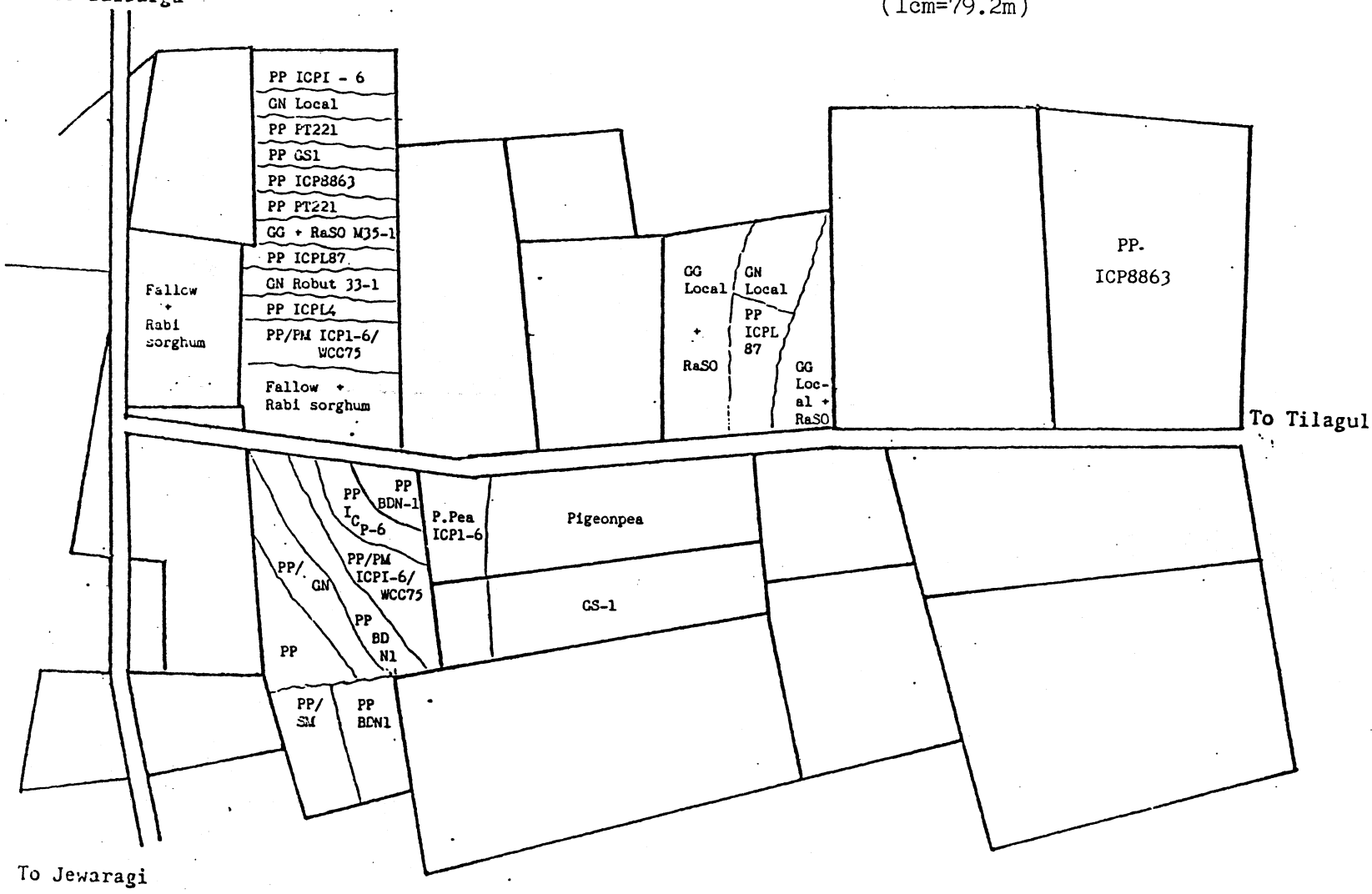


Fig. 2: Non-conditional probability (W) and conditional probability >10mm rainfall when preceded by a wet week (W/W); a dry week (W/D) and mean weekly rainfall in Gulbarga taluk 1951-79 except 1979.

Key: PP = Pigeonpea
GN = Groundnut
GG = Greengram
RaSO = Rabi Sorghum
SM = Sesamum
PM = Pearl millet

Fig. 3: FARHATABAD VILLAGE WATERSHED - GULBARGA DISTRICT
CROPPING SYSTEM 1984-85

Scale 1" = 660'
(1cm=79.2m)



INCREASING PRODUCTIVITY OF SMALLHOLDER RICE FARMING SYSTEMS IN SRI LANKA - A CASE STUDY

U. R. Sangakkara

INTRODUCTION

Rice is central to most farming systems in Asia due to its suitability under the prevalent monsoon climates. Governments and people place high priority on rice production due to the importance of the crop. Increases in production have been significant within the region, and have achieved an annual compound growth rate of 2.9% in the decade 1973-83 (F.A.O. 1984). Current production from 127.4 million ha of this tropical Asian region lies at 401 million MT per annum (F.A.O. 1984; Morris, 1984).

In Sri Lanka, rice occupies approximately 9.26×10^5 ha. The production from this area in 1983 was 2.2 million MT (F.A.O. 1984). The estimated average yield lies around 2357 kg ha^{-1} and land holdings being around 0.5 ha, the anticipated annual yield under existing conditions of smallholder rice farmers in Sri Lanka is around 1200 kg for both seasons. Price of unhulled paddy at current market rates is approximately SLR* 3.00; gross income of farmers per year is SLR 7200.00. This is a low income level for an average farm family, especially as potential exists to increase their incomes by better land and resource utilization.

A major technique in increasing land and resource utility is the adoption of intensive cropping systems (Zandstra et al., 1981; Morris, 1984). This is feasible in traditional rice culture in Sri Lanka, as approximately two months exist between rice seasons. Due to the availability of adequate soil moisture, short-term crops could be fitted into this period to utilize the family resources better, as done at IRRI (IRRI, 1983) and elsewhere in the Philippines (Price, 1984).

Research has highlighted the suitability of short-term grain legumes (both seed and vegetable types) for increasing productivity of rice farming systems (Gomez and Gomez, 1983; IRRI, 1983). These legumes are accepted by farmers, fetch high prices, and enrich soil nitrogen. They also play a vital role in alleviating malnutrition problems in the developing world.

The study reported in this paper evaluated the effectiveness of two selected legume crops in increasing the productivity of a rainfed farming system in the mid-country of Sri Lanka. A rainfed system was selected as it is the predominant feature of rice farms in the region. The evaluation was based on the yields of rice and legumes, labor use, and income generating patterns of the systems.

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* 28 SLR (Sri Lankan Rupees) = 1 U.S. $.

SETTING OF THE STUDY

The study was carried out during the period October 1984 to September 1985 at Peradeniya, Kandy (7°N, 80°E; 425 m above sea level), in the central province of Sri Lanka. Three adjacent farm fields (identified as A, B, C) were selected, and each consisted of approximately 0.41 ha of rice fields. The rainfall and temperature patterns at the site during the trial are given in Table 1, and the soil characters are presented in Table 2.

The farms were selected as typical of subsistence rice holdings in Sri Lanka, as over 75% of their annual income was derived from rice yields. All farms were owner cultivated using family and exchange labor. Hired labor was used during transplanting and harvesting.

The selected farmers have cultivated their rice fields in both seasons for the past 15 to 20 years. The interseasonal periods have always been left fallow and no attempt was made to use the land and available soil moisture during this period.

MATERIALS AND METHODS

The trial, designed as a factorial experiment with four replicates (Gomez and Gomez, 1976) was initiated in September 1984. The selected cropping systems were carried out on all three farms. The inputs and technical advice was provided by the researcher and labor by the farmer. The latter was entitled to the produce at the end of each season.

Rice (variety BG 400/1) was transplanted from a lowland nursery at a spacing of 10 x 20 cm, after traditional land preparation in October 1984. A fertilizer rate of 30:20:20 N:P:K ha^{-1} was used for the crop, as locally recommended. The rice fields were drained at the golden ripe stage of the crop, and plots were harvested in mid-February. Unhulled rice yields were measured by traditional methods and converted into kilograms per hectare.

Bush beans (*Phaseolus vulgaris* L. - Variety Top Crop - 45 days) were sown soon after the rice crop with minimal land preparation, at a spacing of 10 x 20 cm. This crop was established on four plots in each farm. Four other plots were broadcast with a green manure crop (Sunhemp - *Crotalaria juncea* L.) at the same time, again after minimal land preparation. The remaining plots were left fallow as in traditional systems. The bean crop was fertilized with a 5:15:15 N:P:K mixture one week after planting. The sunhemp was not fertilized. Beans were harvested from the 30th day on three occasions at seven day intervals.

All plots were prepared for the second crop of rice with the onset of rain in April 1985. The stubble of the previous rice crop, the crop residue of beans, and the sunhemp (which was at 40% at flowering) were incorporated into the soil. The rice crop (variety BG 34/8) was transplanted from a lowland nursery in early May and was managed in a similar manner to the previous rice crop. This crop was harvested in early September 1985 and yields measured.

Daily labor use patterns of farmers was monitored by noting the number of days worked by the farmers in tending the crops. The final incomes derived from the different systems were calculated on the basis of commodity prices prevalent at the time of harvest of each crop.

RESULTS AND DISCUSSION

Table 3 indicates the rice yields obtained during the first season of cultivation. There were no significant differences between the three farms, and the yields were above the national average. This increase could be attributed to the adoption of improved cultural practices by the farmers due to the participation of the researcher. This result highlights that farmers in Sri Lanka can respond to proper extension facilities, as shown by Sivayoganathan (1984), and are capable of improving their yields.

The legume was planted with minimal land preparation. No problems were observed with the cultivation of beans, and farmers readily responded to the technology. Bean yields (Table 3) did not differ between farms and although yields were low, the crop provided the farmer a means of utilizing the land previously left fallow.

The sowing and maintenance of sunhemp required little labor, and the farmer did not obtain an economic yield from this crop. However, incorporating this crop at 40% flowering with the crop residue of bush beans increased subsequent rice yields (Table 4). The mean yield of plots left fallow was the lowest (3114 kg ha^{-1}) and the plots which contained sunhemp yielded the most (4056 kg ha^{-1}). The yield increase of 29% could be associated with the added nitrogen and organic matter added to the soil by the green manure crop; such crops have a significant effect on yields of the succeeding rice crop (Pandey and Morris, 1984).

The yields of rice obtained from plots incorporated with the bean crop residue indicated a 6% increase over the control (Table 5). As stated by Staker (1958) and Pandey and Morris (1984), the results show that the green manure crop is significantly better than a legume from which a crop is harvested in terms of increasing rice yields.

Economic evaluations of the different types of cropping adopted are presented in Table 5. These ilustrate the high income generating potential of harvestable legume crops due to the higher prices fetched by the produce. The bean crop increased gross incomes by approximately 50% compared to land left fallow, without disturbing normal crop calendars. This is a profitable and feasible venture although subsequent rice yields are not greatly increased by the introduction of this crop.

Due to unforeseen changes in weather patterns, the interseasonal periods may be shorter than anticipated, thus not providing sufficient time for the bean harvest. Under such circumstances, the use of a green manure or plowing of an established legume crop as a green manure is a feasible alternative. Results of this study indicate that such a practice increases

rice yields, bringing a higher gross income of approximately 14% when compared to a fallow rice cropping system.

Analysis indicated that interseasonal cropping of a harvested legume crop and sunhemp increased labor requirements by 45% and 5% respectively when compared with the fallow system.

CONCLUSIONS

Sequential cropping is considered the most suitable cropping pattern for increasing productivity of rice fields (Gomez and Gomez, 1983). This study highlights a situation where an upland legume crop is grown during the interseasonal period.

A few problems exist in adopting sequential cropping patterns. The unpredictability of weather could shorten the time period between the two rice crops. In such instances, a green manure crop will be the most suitable. The lack of capital and the unwillingness of farmers to adopt these practices could also be considered as setbacks. Thus, credit facilities and extension services will play a vital role in promoting these cropping systems to rice farmers.

A shortcoming of this study is the short-term nature of the investigation. This is currently being rectified and long-term trials are planned to evaluate many legume and non-legume species as interseasonal crops. The long-term effects of these crop combinations will be evaluated to develop alternative sequential cropping systems that are productive and useful to smallholder rice farmers.

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Table 1

Monthly rainfall data (mm) and mean monthly temperature (°C) at the experimental site.

Month	O	N	D'84	J	F	M	A	M	J	J	A	S'85
Rainfall	212	322	185	78	43	174	191	180	225	138	88	94
Temperatures (°C) (mean-maximum)	28.8	29.0	28.1	29.3	30.4	31.4	31.2	30.7	27.4	27.7	27.4	29.0
Temperature (°C) (mean-minimum)	19.0	19.4	18.3	19.3	18.7	20.1	20.3	21.3	20.5	20.3	19.9	19.5

Table 2

Soil characters of the experimental site.

Soil type	- Low Humic Gley associated with Immature Brown Loams
Soil color	- Dry 10 YR 5/8 - Yellowish brown
	Wet 10 YR 3/4 - Dark yellowish brown
Texture	- Clay loam
pH	- 4.85 (1:2.5)
% N (Total)	- 0.18%
% Carbon	- 1.96%
CEC (NH_4OAC - pH.7.0) 2042 millimole kg^{-1}	

Table 3

Yields of unhulled rice (1st crop) and bush beans (interseasonal).

	Yield kg ha^{-1}	
Farm	Rice	Bush Beans
Farm A	3245	1756
Farm B	3028	1920
Farm C	2985	1704
S_x-	240	194

Table 4

Yields of unhulled rice (kg ha^{-1}) planted after bush beans, sunhemp and in fallow plots.

	Yield kg ha^{-1}		
Farm	Bush Beans	Sunhemp	Fallow
Farm A	3316	4042	3127
Farm B	3224	3824	3204
Farm C	3296	4204	3021
S_{x-}	182	278	95

Table 5

Gross income of the three different cropping patterns (SLR per 0.5 ha*)

	Income SLR per 0.5 ha		
Farm	Bush Beans	Sunhemp	Fallow
Farm A	14231.50	10930.50	9558.00
Farm B	14178.00	10278.00	9948.00
Farm C	13681.50	10783.00	9009.00

* Income expressed as SLR per 0.5 ha as average farm size approximately 0.5 ha.

Prices calculated as - Unhulled rice SLR 3.00 per kg

Bush beans SLR 5.00 per kg

28 SLR = 1 U.S. $

EXPERIMENTAL DESIGN

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RESOURCE-EFFICIENT EXPERIMENTAL DESIGNS FOR ON-FARM RESEARCH

T.C. Barker, C.A. Francis, and G.F. Krause

Farming systems research and extension, (FSR/E), seeks to identify limitations to food production capabilities in the context of farm family needs and resources. It is assumed (perhaps dangerously) that FSR/E involves the appropriate specialists, integrates the research objectives among these disciplines, and includes farmers both in the research process and in the evaluation of new technologies. Given these assumptions, this paper focuses on some specific tools needed for cropping systems trials on farms. We suggest experimental design criteria needed for on-farm crop research, summarize the utility of four designs commonly used in FSR/E, discuss the applicability of two relatively uncommon designs with potential for on-farm research, (OFR), and suggest some areas for future methodology development.

CRITERIA FOR ON-FARM EXPERIMENTAL DESIGNS

Gomez and Gomez (1984) provide a thorough review of considerations in OFR. This includes the types of data to be collected:

* Physical and biological environment of the farm
* Social and economic data
* Current farmer's practices and their productivity
* Productivity or yield measurements of new technologies
* Data that are expected to help explain the performance of each test factor

We will limit our discussion to experimental designs to optimize the latter two types of data collection.

The type of experimental design chosen should be dictated by the specified objectives of the research and the resources available. Cochran and Cox (1960) provide time-proven guidelines for clarifying the purpose of research prior to designing an experiment. The objectives usually fall into two categories: Treatment effect comparison and response estimation. Treatment effect comparison involves separating significantly different effects or identifying superior technologies, such as comparing the yield potential of a number of genotypes or the effect of various fertilizer amendments on soil test levels. Response estimation seeks to describe functional relationships or trends in response, such as the effect of increasing plant density on number of tillers in a small grain, or the relationship between yield and fertility level.

On-farm research may also be classified as "technology generation" or "pure research" vs. "verification" or "extension" (Gomez and Gomez, 1984; Barker, 1985). However, this distinction is largely a question of the nature of experimental objectives, specification of the level of farmer involment in field operations, how much direct technical supervision is necessary, and how readily transferable or "practical" are the results. A given design, e.g. a

randomized complete block design (RCBD), may be utilized either in "research" or "verification" on farms.

There may, in fact, be a continuum of trials intermediate between pure research and pure extension. Given limited time and resources for research, it would be advisable to combine both research and extension objectives in a single trial and/or at a given site. The remainder of this paper considers experimental design objectives on the basis of "treatment effect comparison" vs. "response estimation" rather than "research" vs. "extension".

Given clearly specified research objectives, a second important consideration for OFR is the availability of suitable land and resources. Areas of uniform soil are often limited, particularly in marginal upland areas. Such areas also present transportation difficulties for the research personnel as well as for research supplies, samples for analysis, and communication of analytical results. For example, the Program on Environemtnal Science and Management (PESAM) of the University of the Philippines has outlying research stations in nine regions of the country where upland OFR is conducted. Several of these sites are on different islands, and on a given island, roads to the uplands are usually rough and subject to wash-outs following intense rains. Upland crop production sites, shifting cultivation fields in particular, tend to be small, irregular, and of non-uniform soil. Thus, experimental designs in support of FSR/E in many lesser developed countries must contend with limited land, inadequate transportation, and scarce research resources.

On-farm research in the U.S. and other more developed countries may share soil uniformity and transportation difficulties to some extent, but are more apt to be constrained by limited research funding. Given limited budgets, there is seldom support for on-farm trials comparable to that available for studies on research stations.

Thus, an experimental design for on-farm trials should address the objectives of the research, and consider the limitations in land availability and other experimental resources including supervision. In addition, involvement of farmers in the research process, both during design and assessment, should be emphasized. This is an area where agronomic methods have lagged behind the social and economic sciences in FSR/E, due partly to the difficulty in controlling experimental conditions or specifying farmer input into decision-making as a study factor. As Lightfoot (1983) noted, "Farmers' involvement in these experiments would usually extend only to the lending of land". Farmers' interaction with on-farm researchers is not only a practical means of direct extension of research results, farmers themselves are often very creative innovators. Thus, the criteria for on-farm experimental designs should include:

* Compactness and minimum numbers of observations (plots, experimental units) for meeting objectives
* Simplicity of design, field arrangement, data collection and analysis
* Flexibility in terms of farmer's input and aptness to farmers' conditions

COMMONLY USED EXPERIMENTAL DESIGNS

To date, on-farm cropping systems research has utilized experimental designs practically identical to those used on research stations, the main difference being restricted numbers of treatments and replications. We briefly evaluate four commonly used designs in terms of the criteria listed above. The reader should refer to Cochran and Cox (1960), Gomez and Gomez (1984) or other experimental design texts for full details.

Randomized complete block designs (RCBD) are used for many purposes, and are perhaps the most widespread type of field layout found in either research stations or on-farm trials. Depending upon the treatments specified, the RCBD may be used for either treatment differentiation or response estimation (e.g. a complete factorial arrangment of treatments). A simple RCBD may be quite compact and simple to design, implement, and analyze, and therefore appropriate for on-farm use. However, with increasing complexity of experimental objectives, the number of treatments and size of replications may increase beyond land availability and resource limitations. For example, a complete factorial to study three factors at three levels for response surface estimation would require 3^3, or 27 treatments per replication. If replicated a minimum of two times, one would need 54 plots -- a large number for many on-farm situations, especially if the farmer is expected to administer all treatments.

Split plot designs (SPD) are most useful where interactions between main treatments and sub-treatments are of primary interest. For intance, Barker and Sajise (1985) used a SPD with five cowpea (*Vigna unguiculata*) genotypes as main treatments, and sub-treatments of artificial inoculation vs. no inoculation to evaluate the interaction of the cowpea lines with inoculation in acid soil conditions in a shifting cultivation on-farm trial. Thus, the differentiation of treatment effects and interactions is the usual reason for using the SPD. It would be possible to use the SPD for response estimation since sub-treatments may be a given variable at several levels. However, it is seldom used for response estimation due to the unequal variances of means arising from different plot sizes required by the SPD. The SPD generally requires a more complex analysis than the RCBD.

Lattice designs (LD) facilitate the comparison of a large number of treatments which are assigned to incomplete blocks within replications. Cochran and Cox (1960) present numerous lattice designs, capable of handling up to 144 treatments in uniform blocks of 12 (a 12 x 12 quadruple lattice) as opposed to the 144 uniform experimental units per replication required for the RCBD. While the lattice and other incomplete block designs allow for "compactness" in terms of the area of uniform soil required for blocks, they still require the same total number of experimental units. In addition, they are considerably more complex to design, conduct, and analyze than the RCBD.

Fractional factorial designs (FFD) are used for exploratory estimation of responses and interactions, and are composed of smaller blocks than the full factorial arrangement of treatments in a RCBD. Like the lattice designs, the FFD is advantageous in terms of space saving per block, but

still requires a large total number of experimental units. Furthermore, the FFD design and analysis is quite cumbersome, and likely too complex for routine on-farm use.

As the above comments suggest, there is much room for choice of experimental designs for on-farm cropping systems research which will improve their compactness and simplicity. To our knowledge, little statistical methodology development has been done specifically for on-farm cropping systems trials, except that of Gomez and Gomez (1984) which is a modification of the RCBD and complete factorial. Thus, the scientist is obliged to use one of the above designs, trimmed to as few observations as possible to address the research objectives. Two experimental designs which are relatively uncommon, neither of which were developed for OFR, may have utility in certain on-farm situations. A general presentation follows on the construction of augmented and central composite designs, with examples of their use and suggested application to OFR.

"UNUSUAL" DESIGNS WITH POTENTIAL ON-FARM APPLICATION

Augmented designs (AD) were developed by W.T. Federer (Federer, 1956; Federer and Raghavarao, 1975) for use in plant breeding experiments. The basis for this design is a "Standard design plus additional treatments...in the blocks or cells of the design" (Federer, 1956). As originally implemented, the main treatments of the "standard" design were advanced breeding lines or varieties with sufficient seed for replicated trials. The "additional" treatments within each block were breeding lines with sufficient material for only one observation or plot. Thus, an augmented RCBD might include several main treatments (lines) per replication which constitute the "standard" design, with a number of additional treatments (lines) unique to each replication. An example of an augmented RCBD from Federer (1961) is as follows:

Group 1	Group 2	Group 3	Group 4
A	A	A	A
B	B	B	B
C	C	C	C
D	D	D	D
e	h	k	n
f	i	l	o
g	j	m	

where upper case letters represent standard treatments, and lower case letters represent augmented treatments. The augmented design makes it possible to formally evaluate the non-replicated lines (e-o). Federer (1956) outlined the design and analysis of augmented RCBD and latin square designs, including the general analysis of variance and comparison of standard treatment means vs. augmented treatment means as well as comparisons among augmented treatment means. Later papers (Federer, 1961; Federer and Raghavarao, 1975) discuss additional augmented designs, and augmentation in incomplete blocks.

Barker (1985) proposed an on-farm trial using an augmented RCBD to evaluate the productiviy of several forage legumes overseeded into soybeans for fall/winter ground cover and spring green manure. This trial specifies six legume species as standard replicated treatments, and requires that additional legume species of the farmers' choosing be added as augmented treatments. Therein lies the unique contribution of augmented designs to on-farm cropping systems studies -- the flexibility to add farmer-chosen treatments to an on-farm experiment at a given site. The proposed on-farm study with soybean overseeding would be conducted at several sites, each having unique augmented treatments in addition to the standard "core" RCBD treatments. This approach could encompass many experimental objectives in on-farm research, such as tillage methods, fertility amendments, and weed control alternatives. In each case, the primary benefit would be that each cooperating farmer could add innovative treatments into a formal evaluation as part of that site's experiment. Alternatively, augmented treatments could allow rapid screening of additional researcher-specified treatments. The "standard" treatment analyses are readily combined over locations and seasons, and it should be possible to combine augmented treatment analyses over seasons. Thus, the augmented designs provide a unique opportunity to facilitate farmer input and rapid technology screening into on-farm cropping systems research. We suggest that this type of farmer involvement is critical to effective on-farm research with alternative cropping technologies.

Central composite designs (CCD) were developed by Box (1954) and Box and Hunter (1957) to reduce the number of treatment combinations required for response surface estimation. Hader et al. (1957) extended the CCD to agronomic studies, and these authors as well as Cochran and Cox (1960) and Barker (1984) provide more details on the design, layout, and analysis of the CCD. These compact designs facilitate response surface exploration and permit estimation of interaction effects, optimum points, and prediction equations.

The primary benefit of the CCD is in reducing the number of experimental units needed to estimate a second-order response surface polynomial. The estimation of a complex response surface is possible in a small area of uniform experimental material. For example, Barker (1984) used a CCD to study sweet potato and cowpea yield responses to N, P, and K on shifting cultivators' fields. The design required 20 plots, as opposed to 3^3 or 27 plots per replication in a full factorial RCBD. Thus, 108 plots are required for a complete factorial RCBD with four replications to provide the response surface estimation possible from 20 plots in a CCD. Cochran and Cox (1960) provide plans for additional CCD's, including up to six variables, and plans for CCD's in incomplete blocks. Like the lattice and fractional factorial designs, however, the CCD is relatively complex, and its complexity increases when incomplete blocks are utilized.

Compared to other experimental designs used for response estimation, the CCD offers considerable savings in the total number of experimental units required. It shold be possible to combine results of the CCD over locations and over years, but to date little work has been done with applications of the CCD or other response surface methodology designs to field crop studies. (Mead and Pike, 1975).

RESEARCH NEEDS

Currently available experimental designs do not fully meet OFR needs. However, the fact that two designs were identified "off the shelf" and applied to the on-farm setting suggests that practical experimental design development could lead to significant improvement of designs for on-farm research. We suggest methodology development is required in the following areas:

* New designs which better address soil and other variations among experimental units and among farmers, e.g. compact designs which perhaps easily facilitate analysis of covariance
* Response estimation designs which accomodate farmer innovations, such as the augmented design; perhaps an augmented central composite design
* Microcomputer software programs (such as Michigan State's MSTAT) specifically for on-farm situations and LDC applications: these would include:
  1. Software develoment to simplify analysis of presently available designs such as FFD and CCD
  2. Software development to facilitate analysis of results over locations and over years

In addition to the improvement of experimental designs for OFR , innovative approaches to studying cropping systems on farms which could help improve the simplicity, compactness, and farmer involvement in research and extension efforts merit further attention. These include:

* "Overlaying" of treatments on existing fields (Lightfoot, 1983)
* Data collection by farmers for survey/semi-structured field trials without direct researcher supervision (Barker, 1985)
* The efficiency of using various levels of replication depending upon experimental objectives (Gomez and Gomez, 1984, Chapter 16)
* Development of response curves to support computer models which lead to less dependence on complex trials over a large number of sites (Barker and Francis, 1985)
* Evaluation of yield stability and risk in cropping systems in addition to total yields and net returns
* Covariance of yields of two or more crops
* Comparison of cropping systems performance on the basis of total biomass production, total nutritive value, or other absolute criteria rather than relative yields from dissimilar crops
* Comparison of alternative cropping systems where components are dissimilar

CONCLUSIONS

As pointed out by Lightfoot (1983), field plot techniques for farming systems research have largely been "miniturized research station experiments"

and have lagged behind socioeconomic methods, particularly in the direct involvement of farmers. While augmented and central composite designs do not completely fill the gaps in needs for on-farm experimental designs, they each provide at least one unique benefit which merits consideration. For treatment comparison trials, the augmented design permits flexibility in involving farmers directly in the definition of treatments. For response estimation experiments, the central composite design offers a dramatic reduction in the number of plots required and therefore a savings in scarce research resources and land suitable for field trials.

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FARMING SYSTEMS IN AREAS OF FARMER-HERDER INTERACTION IN SEMIARID AFRICA: TOWARDS AN APPROPRIATE MODEL FOR INVESTIGATION

Mamadou Diop Geoffrey O. Livingston David J. Campbell

INTRODUCTION

Over much of semiarid Africa agricultural systems are characterized by significant interaction between livestock and cropping systems. FSR/E currently has an identifiable bias towards cropping systems to the neglect of livestock systems. This is understandable in that for a variety of reasons research into increasing crop production has been deemed more important: there are more farmers than herders; crop production is usually a greater contributor to GDP than of livestock; the sedentary nature of farming makes research easier; farmers have been viewed as being more amenable to change; it is easier to conduct research among farmers than among herders; and there has tended to be an institutional bias against herders which discourages research into livestock systems (Bernstein, 1982; Eicher and Baker, 1982).

The relative neglect of livestock systems assumes critical importance in the context of cropping systems research where there is considerable interaction between farmers and herders. In these circumstances a farming systems model is needed which has a structure with the versatility to incorporate the characteristics of each production system and the complexity of the interaction between them.

The objective of this paper is to propose a model for examining African production systems in which cropping systems and livestock systems overlap spatially and interact economically, socially, politically, and environmentally. The purpose is to develop an approach which might be more appropriate to the study of interactive systems. This may provide a basis for devising FSR/E strategies more relevant to the design of suitable technologies for Africa's semiarid lands.

The paper will first briefly discuss similarities and differences between cropping systems and livestock systems and describe their interaction. Subsequently a model for studying cropping systems and livestock systems interaction will be discussed.

INTERACTION BETWEEN LIVESTOCK SYSTEMS AND CROPPING SYSTEMS IN SEMIARID AREAS OF AFRICA

The semiarid areas of Africa are characterized by significant interaction between livestock systems and cropping systems (Matlock and Cockrum, 1976; McCown, et.al., 1979; Wilson, et.al., 1983). Livestock systems, be they transhumant such as the Fulani (Hopen, 1958; Stenning, 1959; Dupire, 1962, 1972; Gallais, 1969, 1979) and the Maasai (Jacobs, 1963, 1975; Galaty, 1980) or migratory such as the Tuareg (Rognon, 1962; Nicolaisen, 1963; Mortimore, 1972; Swift, 1975; Bernus, 1979; Bourgeot, 1979), and Somali (Lewis, 1961; Swift, 1977; Box, 1971), are closely adapted to the constraints of a highly seasonal distribution of water and pasture. While dispersed

during rainy seasons, herders concentrate during dry seasons and droughts around permanent sources of water and pasture. These are located where rainfall is heavier and more reliable or around perennial rivers or swamps. The reliability of the water source provides many of these dry season retreat areas the potential for crop production and farming communities are frequently found within them. During dry periods significant interaction between herding and cropping systems takes place. These two systems differ in such aspects as their production strategies, production cycles and use of land but interaction with respect to trade, land use, and animal management renders them interdependent. In order to understand the distinctiveness of each system and the nature of their interaction, salient features of cropping systems and livestock systems will be discussed.

Livestock Systems

Livestock systems in Africa are predominantly oriented towards subsistence production. A variety of animals (cattle, camels, sheep, and goats) are kept and managed to produce different outputs, milk, meat, and hides, in areas with severe environmental constraints (Pratt and Gwynne, 1977; ILCA, 1983). Rainfall is low in amount and is unreliable over time and space. This imposes limits on the availability of water and pasture such that migrations over wide areas are necessary to ensure the productivity of the herd throughout the year.

To provide for the needs of their populations, herding societies have developed complex management strategies (Widstrand, 1975). These involve keeping a herd of different species with a composition and size which can provide for the various requirements of the community. The herd must be of a size sufficient to meet subsistence needs, needs associated with trade and social obligation, and to allow for a risk factor to cope with the effects of disease or drought (Baker, 1974; Dahl and Hjort, 1976; Hickey, 1976). This herd must have access to an area which provides grazing and water throughout the year without endangering the long term productivity of the land resource (Western and Dunne, 1979).

The livestock represent the capital of livestock systems. Investment decisions regarding the herd can only pay off once animals become productive. Given the length of time between conception and productivity, decision-making among herders necessarily has a longer time horizon than that of farmers. It also involves higher risks. The necessity to minimize risk within a long term production cycle has implications for land use and for the allocation of labor. Labor requirements vary from season to season and are at a peak in the dry season and during droughts when the herds have to be split into smaller units. The allocation of labor is the responsibility of individual families but will often involve sharing of resources from the extended family and the established linkages between clans, age sets and other social units.

The use of land is, in contrast, controlled on a communal basis. The rangeland territory contains specific sites where dependable water and pasture can be found in dry periods. At these times other scattered but unpredictable areas will also be available. These resources are valued by the whole society and the movement of herds has to be managed communally to

prevent both privatization and over exploitation (Gilles and Jamtgaard, 1981).

The difficulty of management is increased by the nature of the principal product of the livestock systems, milk, which has to be harvested daily and is highly perishable. To maintain a regular supply of food, the inputs, water and pasture, have to be readily accessible and careful management is essential to achieve this.

The basic components of a livestock management system are presented schematically in Figure 1. When consideration of the system is made over an appropriate multi-year time frame, over a large area, and when each component is elaborated upon, the full complexity of livestock systems becomes apparent. It represents an interaction between social, economic, political, and environmental factors. At the social level the different needs of family and group have to be balanced; the economy has to provide for both subsistence and exchange; the long term productivity of the environment has to be maintained; and political issues between different herding groups, between herders and farmers, and between herders and government authorities have to be resolved. Over much of Africa the transition through the colonial period from pre-colonial times to the present resulted in major disruption of livestock systems and many can be viewed as in a state of continuing adjustment to the opportunities and constraints of colonial and post-colonial circumstances (Gallais, 1972; Bugnicourt, 1974; Bourgeot, 1981; Galaty, et.al., 1981; Sandford, 1976, 1983).

Cropping Systems

Cropping systems in semiarid Africa are also complex. They are subject to similar environmental constraints as livestock systems and farmers have become more directly affected by and involved with colonial and post-colonial political, social, and economic trends than herders (Nicolas, 1960; Raynaut, 1971, 1975; Bernard, 1972; Knight, 1974).

The climatic constraints identified for livestock systems also affect cropping systems in semiarid areas. The rainfall is limited either to one rainy season, as over much of west and southern Africa, or to two shorter ones, as in parts of east Africa. Crop production has therefore to take place within the limited period for which moisture is available for plant growth (Cochemé and Franquin, 1967; Porter, 1979).

The choice of cash and subsistence crops is limited by both rainfall and soil conditions. The variety of soil types within the catenas of semiarid lands represents different crop production potential over a relatively confined space. As farmers seek a variety of resources, farms are frequently composed of a number of non-contiguous plots distributed across the catena. On these plants suited to the particular soil will dominate within a mixed cropping system (Ruthenberg, 1980).

Recent social and economic changes have resulted in a move away from farms owned by the extended family towards nuclear family ownership (Eicher and Baker, 1982). This, together with population growth, has led to

subdivision of farm plots into very small units on which cash cropping has often increased at the expense of subsistence crops.

The pattern of land use in cropping systems is made up of a mosaic of farms. Cropping decisions, made by individual farmers, reflect the socioeconomic standing of the farmer, the environmental potential of the land, and the traditions of the society. The farmers' strategy is not one of continuous production for subsistence but rather is based on the harvest cycle. The harvest has to supply food throughout the year but crops, as opposed to milk in livestock system, are less perishable. Further, the long term productivity of the main capital resource, the farm land, is achieved by an active transformation and management of the physical environment on a fixed land area.

The major components and interactions of cropping systems are clearly illustrated in farming systems studies (Gilbert, et.al., 1980; Norman, 1980; Norman, et.al., 1982; Shaner, et.al., 1982). The area of a farming system is defined on the basis of similarities in farm practices, social circumstances, and ecological conditions. In practice the basic spatial unit in terms of production decisions is that of the farm and the time frame over which the system acts is the harvest cycle.

Similarities and Differences

The rudimentary sketches of livestock systems and cropping systems outlined above signal commonalities and differences important to a discussion of the agricultural systems found in semiarid areas of Africa. The major similarity is the dynamic interaction each has with the environment. It can be argued that herders have adapted their livestock systems <u>to</u> the environment more than farmers who adapt the environment to their needs by replacing the natural vegetation with crops, by terracing or ridging and by manuring. However, both farmers and herders attempt to maintain the quality of their land over time by managing their crops and livestock in ways which reduce the risk of environmental deterioration. These management practices reflect an organization of the livestock systems and cropping systems which has been learned and adapted over centuries.

While these similarities exist there are also differences which are important to an understanding of their interaction. The most important is the question of time. In livestock systems the time between birth and production varies between a year for sheep and goats and about four years for cattle (Wilson, et.al., 1983). Once productivity is attained then the output, milk, can be stored for only a very short time as it is highly perishable. In addition, the seasonal fluctuations in availability of water and pasture impose a medium term time constraint upon livestock systems. Herders, therefore, have to manage their activities with a complicated and interrelated system of short, medium, and long term requirements. These recognize long and medium term environmental variability which imposes a need for mobility, access to resources over a wide area, and risk minimization skills. These in turn create variable labor inputs over time with the maximum being required during dry periods when access to water and pasture is most difficult.

Cropping systems are also vulnerable to long term environmental variations but the production cycle is much shorter, being associated with the annual highly seasonal rainfall distribution. In that the time from sowing to harvest is relatively short, the labor requirements are more predictable and are applied to a fixed and known land area. The crops are not as perishable as milk and so the daily production required of livestock systems is replaced by a daily allocation of harvested products which have to be stored to provide year round nourishment.

It is evident therefore that environmental, temporal, biological, and organizational factors are relevant to a consideration of agriculture in areas of interaction between cropping systems and livestock systems. The nature of the interaction can be characterized by three types of linkage: ecological, exchange, and competition (McCown, et.al., 1979).

Ecological linkages develop as a response to the mobility of herds which brings them into cultivated areas during dry seasons and droughts. Access to these better watered rangeland margins is essential to the survival of the livestock systems. The annual basing of livestock in farming areas not only assures their survival as they graze stubble and fallow but, through the dropping of manure, improves the fertility of soil. Herders benefit by having access to residues which are of higher nutritive value than the dry natural pasture and the farmers have their fields fertilized.

Exchange linkages relate to transactions by which livestock products are traded for farm products. These mostly involve the trading of milk, meat, and hides for grains. In areas where there is a land shortage and fallowing is no longer possible, a farmer may be willing to pay to have animals graze in the fields to obtain the manure. Contrarily, if there is not enough pasture available, farmers may charge herders for the right to graze on residues.

Many of the ecological and exchange linkages mentioned above are of long standing and form an integral part of both livestock systems and cropping systems in semiarid areas (Dubourg, 1957; Mainet, 1965; Bernstein, 1976; Ware, 1979). A number of authors have noted a change away from this traditional interaction as population growth, land pressure, and increasing animal ownership by farmers have altered the population/resource balance. Increasingly relations between cropping systems and livestock systems are characterized by competition and, in some cases, conflict (Dresch, 1959; Diarra, 1975; Weicker, 1981; Campbell, 1981; Campbell and Riddell, 1982).

In the past many herding groups were able to control by force access to dry season retreat areas in farming zones. During the colonial period power was transferred from herders to farmers and this control was ended. An expansion in the cropped area consequent upon population growth and cash crop production encroached upon lands formerly exclusively used as pasture (Berry, et.al., 1977; Franke and Chasin, 1980; Clanet, 1982). The situation is further complicated where farmers invest in livestock and restrict the access of nomadic herds to their fields and where herders become sedentary (Toupet, 1974; Cissé, 1980; Salzman, 1980). In a number of areas, conflict between farmers and herders over access to grazing land is not unusual.

Such competition reflects the different nature of livestock systems and cropping systems. These differences have to be comprehended and incorporated in an interactive model if it is to have utility. The following section proposes a framework for modeling such interactive systems.

TOWARDS A MODEL OF CROPPING SYSTEM/LIVESTOCK SYSTEM INTERACTION IN SEMIARID AFRICA

In any area production systems are influenced by endogenous and exogenous factors. The earlier discussion highlighted similarities and difference between cropping systems and livestock systems and where they interact the configuration of a descriptive model will be complex as the system-specific and interactive elements have to be understood.

Critical to a definition and operationalizing of an interactive model are an understanding of spatial and temporal elements. Livestock systems operate over larger areas and are managed within a longer biological time frame than cropping systems. The interactive model should therefore have among its basic parameters an area of focus and a time scale appropriate to the livestock systems under consideration. As the cropping systems will usually function over a smaller area and within a shorter cropping cycle they will be able to fit within the broader framework defined by characteristics of the livestock systems.

It is argued, therefore, that whereas the dominant farming systems model has as its focus the farm, an interactive model would focus upon a dynamic land use system in which interaction between social, political, economic, and environmental elements over time would be the major focus. Such a model would allow for within and between subsystem interaction to be described and would thus be more applicable to areas of cropping systems/livestock systems interaction than existing farming systems models.

One possible configuration of an interactive model is shown in Figure 2 which highlights the different relations which exist between pastoral and farming communities in a semiarid environment and their impact over time upon each community and the broader society. The feedback from the interaction between herders and farmer over time is greater upon land use systems than on societal norms or the broader society. This is illustrated by the difference between the solid and broken lines in Figure 2. The central element in the model is the land use system which defines the allocation of the land and determines the nature of the relationship between the two communities.

The land use system arises from the interaction of system components some of which are common to both herders and farmers and others which are different. Components influencing the system are both exogenous and endogenous. For example, the five exogenous components, climate, law, history, economic policy and politics, contribute to the definition of the land use system and while both societies are affected by them their impact may differ.

Within each society common components with very different forms include land rights, community beliefs and norms and institutional knowledge. Finally, the societies' technology, the manner in which the resources are

managed, applied to the land area completes the definition of the land use pattern of each society. As discussed above, these land use patterns are not only the product of the nature of each individual system but of the interaction between them. Both farmers and herders engage in secondary activities, either off-farm or livestock for farmers or, less frequently, off-farm and/or cropping for herders. These activities produce physical output and define linkages between the two groups. The physical output may be divided into subsistence and surplus. The subsistence is consumed by the farming or herding household. In the case of farmers, the surplus is channeled through the market, exchange linkage, where it may be bought by a member of the herding community. In the case of herders, part of the surplus is directly reinvested as capital by retaining new born stock. Surplus by-products of each production system, namely manure and fodder, are used to great benefit by the other group. This constitutes the ecological linkage which is reabsorbed as an input into the production system. The competitive linkage, unlike the other two, increases inversely with the amount of available land suitable to both groups as well as the amount of capital. These linkages define the nature of socioeconomic relations which may change through time and may even come to influence the exogenous variables.

The product of the interaction between herding and farming societies can be assessed through examination of the resultant land use system. The spatial and temporal scales at which they are defined would be determined by the longest time frame and largest area over which either the livestock systems or cropping systems under study function. Generally the livestock system would define both. These scales would have the advantage of incorporating the essential elements of both subsystems. Further, the time scale would enable the cropping system to be analyzed over a longer time than is incorporated in most FSR/E models and thus permit assessment of longer term issues affecting farm production (Lev and Campbell, 1985).

IMPLICATIONS FOR RESEARCH AND EXTENSION

The models which currently dominate FSR/E have contributed significantly to an understanding of cropping systems. Cropping systems over much of semiarid Africa cannot, however, be understood without reference to adjacent and closely integrated livestock systems. Livestock systems have yet to be modeled as effectively though studies conducted, for example by ILCA, the International Livestock Center for Africa, will contribute to this.

This paper has argued that FSR/E in semiarid areas might benefit from adopting an approach which explicitly recognizes cropping systems/livestock systems interaction and attempts a broader conceptualization of agricultural production systems. Fundamental to this would be a focus upon land use rather than the farm and upon a multi-year period rather than upon annual cropping cycles. While livestock systems and cropping systems can be effectively modeled as separate entities it has been argued that in areas where there is significant interaction between them a different, more comprehensive approach may provide a better basis for FSR/E. An interactive model which focuses upon land use systems rather than on the functioning of production units, the herd or the farm, allows for the distinctive and common elements of cropping and livestock systems to be addressed at appropriate temporal and spatial scales.

There are many situations where one group, farmers or herders, has taken actions to promote its own interests which, while succeeding in the short term, have had negative consequences for the interactive system as a whole over the long term. Had an appropriate interactive model been available then these consequences might have been predicted and remedial action taken.

A recurrent example in semiarid Africa is the expansion of cultivation into drier lands, to the wetter margins of the rangelands on which nomadic systems depend for their dry season and drought period pasture and water. This process increases the potential for exchange and ecological linkage but these possibilities are frequently obscured by the increased competition over access to land which ensues. In a number of cases the expansion of cultivation had little negative impact in the short term. If rainfall conditions were favorable and the process of expansion slow then competition between herders and farmers was slight and exchange linkages, in particular, began to develop. However, with the onset of less favorable rainfall conditions the farmers found themselves unable to maintain crop production and herders' access to drought retreat areas was restricted by the expanded area of cultivation (Dresch, 1959; Campbell, 1981; Santoir, 1983). Measures which succeeded in increasing crop production in the short term proved to be detrimental to the long term viability of both farming and herding systems.

FSR/E in areas of interaction might not be in a position to recognize the potential for such issues were the focus to be restricted to one group and a short time perspective adopted. For example, a recent study of farming systems in northern Cameroon (Zalla, et.al., 1981) was initially designed to examine measures for increasing food production among farmers. The scale of analysis was to be the individual farm and initially it was assumed that production patterns during the year of study were representative.

In the course of analysis it became evident that food production varied from year to year as a result of variable rainfall, the incidence of crop disease and the effects of weeds and insects. The year under study was not completely representative of the production regime and innovation and extension activities based upon the findings of that one year would thus not have been as appropriate as others based upon a longer term perspective.

Further, historical and demographic analyses demonstrated that the land use pattern among the farmers was in the process of change. While farmers had in the past been restricted to the mountains by the presence of hostile neighboring herding groups contemporary conditions were different. The government had reduced the level of hostility and the agricultural area was being extended beyond the mountains into adjacent, lower lying areas (Boulet, 1971; Boutrais, 1978; Mohammadou, 1981).

This change in land use had implications not only for the long term productivity of agriculture but also for the availability of bushland grazing for herders (Campbell and Riddell, 1982, 1984). The Fulani herders, whose raiding activities had formerly restricted the farmers to the mountains, used the lowlands adjacent to the mountains for dry season grazing. The increasing cultivation of these areas thus represented a significant threat to the viability of their transhumant economic system. One consequence was an increase in hostility between the farmers and herders of the area.

The realization that processes of change in the farming system were having repercussions over a wider area and on adjacent production systems led the FSR team to consider a broader spatial scale of analysis, to examine longer term issues and to focus upon regional land use systems as well as the individual farm.

One outcome was an understanding that the process of expansion of the cultivated area into what had been bushland posed a threat to the viability of one of the major strategies which people of the region relied on to reduce the impact of food shortage consequent upon drought or disease. Bushland and fallow areas are the source of a number of foods such as berries, roots, wildlife, and insects which are consumed only in times of difficulty. In addition, for herders, they are often vital sources of grazing during periods of adversity (Campbell and Trechter, 1982).

The process of cultivation of these areas, which was being promoted by extension services, may well have reduced population pressure in the mountains and increased overall food production during times of adequate rainfall. However, it may also have the unintended outcome of increasing peoples' vulnerability to recurrent but unpredictable periods of food scarcity by reducing the availability of wild food sources.

Resort to hunting and gathering is one of a number of strategies which societies in semiarid areas in Africa have developed to reduce the incidence of food shortage (Lallemand, 1975; Bernus, 1980; Watts, 1983; Campbell, 1984). These are integral components of the socioeconomic systems of both farmers and herders and, where they interact, involve reciprocal linkages. Identification of such coping strategies would enable extension activity in FSR/E to avoid weakening the ability of local systems to compensate for declines in production by advocating innovations which might have the unintended consequence of undermining effective coping strategies.

These examples demonstrate the importance of the interactive land use model and of the selection of relevant spatial and temporal scales in FSR/E research and extension. The methodological issues illustrated above apply equally to the other ecological, exchange and competition linkages which exist between farming and herding communities in semiarid Africa. Their nature and importance vary from year to year depending upon the intensity of interaction between the communities. During droughts it is at its most intense while during periods of plenty competitive linkages, in particular, may be less strong. This flexibility in response to environmental variability is an essential characteristic of each production system and of their interaction which enables them to respond to fluctuations in the production environment.

The model presented in this paper illustrates the complexity of interaction between herding and farming systems in semiarid areas of Africa. It provides a basis for the formulation of FSR/E methods which explicitly examine the nature of this interaction at appropriate spatial and temporal scales. Further, in terms of extension, it highlights the necessity of assessing the impact of innovations proposed for one production system, not only on that system, but also on both the system with which it interacts and on the interaction between them over the short and the long term.

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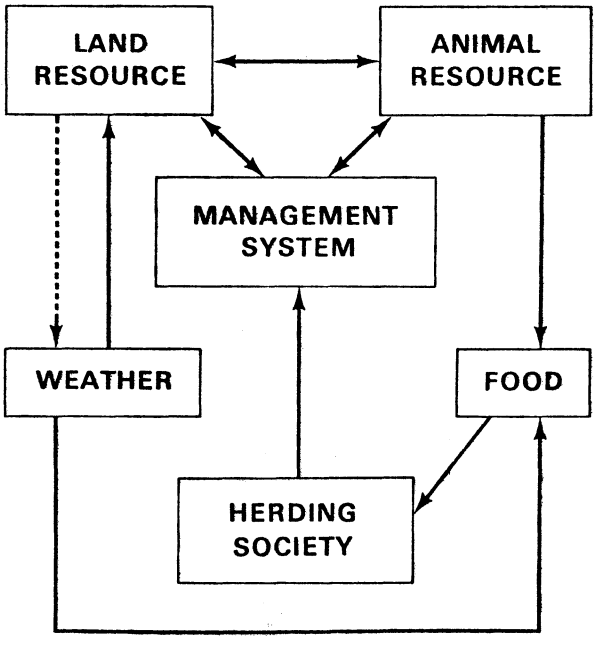

Figure 1. The Livestock Management System.

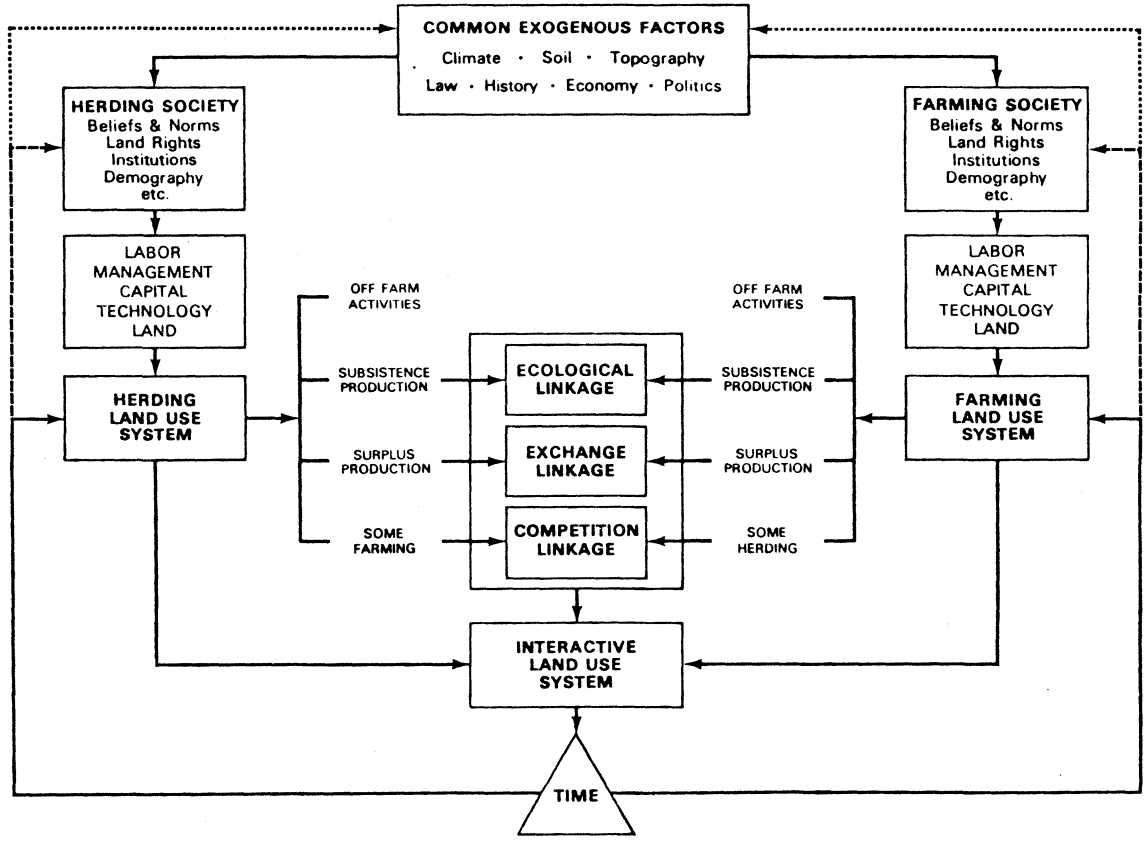

Figure 2. Interaction between livestock and cropping systems in semiarid Africa.

SMALL RUMINANT PRODUCTION IN MIXED FARMING SYSTEMS: CASE STUDIES IN RESEARCH DESIGN

C. Okali and H. C. Knipscheer

INTRODUCTION

Although there are a number of texts describing farming systems research (FSR) methods (Gilbert, et al., 1980; Byerlee, et al., 1980; Perrin, et al., 1976), these are still the subject of debate. The debate essentially revolves around two issues. First, the necessary link between the social and technical sciences that determines the success of the systems research approach. Connected with this is the willingness of each science to adopt unconventional data sets and methods of data collection. The second related issue concerns the importance of on-farm work and the methodological problems raised when undertaking research in the context of the farm.

Since on-farm research, frequently defined as research on farmers' fields (Byerlee, et al., 1980) but used here to mean involving farmers in the research process, is the principal distinguishing feature of FSR, this paper is largely concerned with the design of on-farm work. The relationship between experiment station and on-farm work has been discussed elsewhere (Okali and Sumberg, 1986).

One basic assumption in the paper is that both farm and experiment station activities involve social and technical scientists. In practice, it is often only biologists, breeders, animal scientists, agronomists, and economists who are regarded as essential farming system team members. Agronomists and economists are frequently the only team members working directly with farmers. Collinson (1982), when reviewing on-farm activities, refers only to the biologists' and economists' contribution. The view of on-farm research as carrying out replicated trials on farmers' fields and livestock, and an associated narrow view of relevant data for technology development and testing, contributes to the exclusion of other disciplines. This narrow definition and interpretation is also reflected in the stylized research pattern of baseline surveys, and researcher-managed and farmer-managed trials, which has become institutionalized as FSR. Experience still has to show that this is useful in practice, or even as a tool for teaching purposes. For example, the stages in FSR represent a top-down approach to technology development that basically excludes farmer involvement beyond baseline surveys.[1] While Menz and Knipscheer (1981) attempt to circumvent this problem by linking different types of research methods with various stages in technology design, they also conclude with a top-down approach, farmer involvement being included only as a final stage in the research process.

This paper first describes two small ruminant production systems, one in Java, Indonesia, the other in the humid zone of West Africa, to highlight key features of small farm systems that should determine the way in which on-farm research is designed. Second, the experiences of two small ruminant research teams working in these areas, and of other research programs

working in similar farming system contexts, are used to demonstrate problems in conventional trial designs and the value of a broader view of on-farm research (Table 1).

THE SMALL RUMINANT SYSTEMS[2]

Generally, in both the humid zone of West Africa and in Java, Indonesia, small ruminants are indigenous, unselected breeds that are highly variable, both in size and productivity (Mack, 1983; Sabrani, et al., 1982). Ownership is widespread and average flock size small. Small ruminant production is a subsidiary or minor enterprise; it is not specialized livestock production and it provides a comparatively small proportion of total farm income, although the proportion increases for smaller farmers. In West Africa, contrary to many other farm resources, small ruminants are frequently owned by individuals for whom they might represent a major income source. They are also a convenient source of bulk income. Lagemann (1974) associates the increasing importance of livestock income relative to total farm income in southeast Nigeria with off-farm employment.

The main features of the systems in the two locations are summarized in Table 2. Small ruminant production is a typical, small farmer activity attracting minimum investment in housing, feed, and health care, and largely sustained by the potential of the indigenous breeds themselves. Sharecropping,[3] which reduces cash/capital requirements further, is common to both areas. Crop by-products, kitchen wastes, and in Java, crop residues, are important feed supplements, but in both cases these are not fed systematically. The amount fed and its importance varies significantly between producers and according to season. In general, the actual and potential role of these supplements appears minor. Under confinement in both areas, feed is collected from surrounding vegetation. The end product of these systems is meat production. Livestock are in general kept for sale, although they are widely consumed at religious festivals and during ceremonies.

While this describes the systems in general, two distinct types of management have been distinguished by both research programs: free roaming (extensive) or herding, and confinement of animals. In Java, only sheep are herded, whereas both goats and sheep may also be confined. As in West Africa, owners rarely keep both species (Ashari and Petheram, 1983; Okali, 1979). In most areas in the humid zone of West Africa, the system of production of both sheep and goats is extensive. Two exceptions have been identified to date, the southeastern parts of both Nigeria and the Peoples Republic of Benin, where sheep and goats may be confined. Under confinement, which is associated with more intensive cropping and land scarcity, more investment is required, if only to provide feed, and ownership is more restricted. In Nigeria, the fact that sheep need more attention than goats deters producers from sheep production and restricts ownership to older men who appear to have the time to supervise the grazing. Although similar labor with low opportunity costs (young boys) is used for grazing flocks in Java, sheep are more popular than goats. Lack of time appears to be a constraint on feed collection for confined animals in both

areas.

Differences between the systems in the two locations are relatively small, and this is true also of the extent to which development programs have influenced production. In Java, there has been some introduction of "improved" breeds, while in West Africa there have been attempts to introduce larger breeds from northern savanna areas. Other "developments" in both areas have included the provision of new inputs ("dropping schemes" in Java [Sabrani, et al., 1982]), fattening schemes involving the provision of manufactured feed and factory by-products in Nigeria, and *bergeries*, intensive small ruminant systems in francophone West African villages. None have been introduced on a large scale and small ruminant production systems have, in general, been neglected.

ON-FARM RESEARCH

The Problem

The most important features of these livestock systems for on-farm research is the character of ownership and management of the livestock, small flock sizes, presence of small ruminants in the farming system as secondary or minor enterprises, and variability in the production system. These now well-recorded features raise methodological problems which strike at the core of the debate on what is on-farm research and how the objectives of FSR can be achieved. The problems largely derive from viewing on-farm research as the trial of technologies by individual producing units. In most FSR programs, the involvement of farmers in the actual design of innovations is largely restricted to baseline surveys which may include detailed monitoring of existing production systems. It is from an analysis of these surveys that scientists identify system constraints and subsequently withdraw to design an innovation or seek an already developed technology. The most usual approach once an innovation is identified or developed is for on-farm trials to be instituted by agronomists and economists. The trials are made on a plot or plots within farmers' fields or on a selection of animals where the newly developed system can be contrasted with the existing system.[4] The trials are formally designed to measure productivity differences and, in some cases, move almost imperceptably into demonstrations of finished technologies rather than technologies undergoing a process of adaptation. Other approaches involve farmers working through a complicated series of trials or "kits" (fertilizer, variety, demonstration and production) during which process a whole package of technology is assembled. Both approaches have been utilized by the ACRE project in Sierra Leone for example (Jindia and Tuthill, 1985). The use of "kits" was popularized in West Africa by the International Institute for Tropical Agriculture (IITA) through its involvement in the National Accelerated Food Production Program (NAFPP) in Nigeria.

For a trial to be acceptable scientifically, some control of variables is required, and replication. The trial also has to run to the end of its

course. The method requires that the same design be used on each field (or set of animals), and a sufficient number of observations has to be made for meaningful statistical analysis. Various models demonstrate actual trial findings. Gomez (1977) identified a 60% yield gap between experiment station and farm yield and attributes only a small proportion of this to environmental differences. All other, what we might generally refer to as "socioeconomic", intervening variables that affect trial yield are identified as constraints. While these are clearly constraining a particular trial yield, they are frequently interpreted as constraints to farmers' production and become the focus of a much wider package of technology incorporating credit facilities and other inputs (Table 3). To overcome "traditional" attitudes (conservatism of individual farmers/herders), producers may be encouraged to form groups. The rationale behind the formation of groups emphasizes using group pressure and a sense of group commitment to overcome hesitation/conservatism.

Methodological problems begin with the identification of units of observation as families, households, and farms, all of which have been used interchangeably, frequently to the exclusion of wider units. They proceed with attempts to classify these units according to differences in enterprise management, labor, and the livestock/crop components themselves, for instance, for sampling purposes. They end with large but narrowly focused data sets whose interpretation is based on assumptions about individual production units functioning as independent but unified decision-making units whose primary objective is to achieve substantial increases in total cash income. Rarely is the research designed to respond to producer needs, and most research agenda are set by scientists, research institutions, national governments, or donor agencies (Knipscheer, 1984) rather than the producers themselves.

Units of Observation

The first concern of researchers is to define the units of observation, initially arable, tree crop, livestock producers, and their enterprises, which are the ultimate focus of the research effort. While it is possible to define producers for specific areas and products, the customary procedure is to assume the existence of families that function as single management units. Most of these assumptions also include a man as the head of the unit and key decision maker. The fallacy of this description is now well documented and need not be detailed here.[5] Family farms are multi-product enterprises within which individuals may be responsible for a single product or a group of similar products. They are frequently linked in a management sense with other similar, possibly neighboring, units. The small ruminant systems described are typical examples of such enterprises in West Africa owned by individuals and, in both areas, linked through exchange and management with other systems.

The commonest errors reported in data collection techniques arise from ignoring role sharing within and between production units. In some cases, this leads to a total loss of information. There is still a dearth of information on individual incomes from small ruminants because researchers

insist on merging data at the household level. The Benchmark surveys (Knipscheer, et al., 1980) of the NAFPP in Nigeria excluded information on cassava marketing because only men were interviewed, although women did the marketing (women also frequently owned the crop, but most trial farmers were men). The problem is not restricted to non-social science disciplines. Orlove (1986), an economic anthropologist discussing fishermen and their vendor relatives, who are largely wives, around Lake Titicaca in the southern uplands of Peru, writes, "One cannot really speak of fish as being exchanged between the fisherman and the vendor. Although the incomes of the fisherman and the coresident vendor are not directly pooled, they do form part of the same household budget." This kind of argument reflects a concern with final products rather than with how the products are produced and utilized, whereas to predict effects of policies/projects, the mechanics of production and use should clearly be our concern.

Whole communities can usefully be the focus of trials. In Nigeria, ILCA Ibadan involved two communities in their program to develop an alley cropping model. In their case, farmers were encouraged to experiment with what was called a "working model" (Okali and Sumberg, 1986) and the research in year two was expected to be on the multiple use of foliage by various individuals from the farms. The trial of an already developed technology is also focused on whole communities: annual vaccination with TCRV to control a rinderpest-related disease, *peste des petites Ruminants* (PPR). The testing, started in 1982, involves the use of control and experimental village flocks. Most of the data collected so far are standard livestock productivity data which have already been used to demonstrate the viability of the technology in these terms (ILCA, 1984). Increased livestock production has led to a doubling of flock numbers rather than to increased sales in the experimental villages, and this reaction still has to be explained. The explanation is obviously relevant for policymakers who need to know at what point sales might increase, and for biological scientists who need to be aware of actual rather than potential effects of "improved" production techniques. Meanwhile, of equal importance is the effect of the increased numbers on the environment and any consequent changes in flock management.

In situations where animals are exchanged between owners, as in these small ruminant systems, the whole community of exchange might more appropriately be the unit of observation rather than the individual production unit or even a single community. For purposes of monitoring livestock productivity over time, such a strategy would appear to solve the problem of data loss following the exchange of an animal before a cycle of data collection is complete. There will be problems in identifying these more dispersed communities of exchange.

Reported problems of total data loss often reflect a concern with limited data sets focused on input/output flows from a particular technology. All family/community property is subject to changes in management and may be subdivided or merged with other properties, at which point there is frequently a loss of input/output data, if only due to interruptions in production. Understanding how rights in resources are transferred and under what circumstances they occur, i.e., investment strategies, represents

valuable information that is comparable with numerical data when observed in detail over a number of cases and/or linked with other supporting data, for example, the "field hearings" in Java (Knipscheer, et al., 1986). Such events are not restricted to livestock producers. Okali (1983) describes the transfer of cocoa farms at the death of one participant in her "cost route" farm management survey. While this led to the termination of the farm management data collection on these farms, the details of the property transfer were linked with information already available on how the farms had been operated until that point. She arrived at conclusions about how offspring and wives might acquire rights in cocoa farms from fathers and husbands, and gained insight into how these rights might affect investment in these same properties.

Small and Minor Farm Enterprises

The identification of observation units raises one set of problems; the small size of production units raises another. While the investigation of smallholder family farms is difficult, the difficulty is enhanced when the enterprises are also minor in the system.

A major problem faced when monitoring small enterprises is how to make sufficient observations for conventional statistical analysis. Where the purpose is to monitor flock productivity or the value of production, the common solutions are to increase the time over which observations are made to ensure that infrequently occurring events such as births, deaths, sales, and purchases are recorded, and to take large samples. Mortality of livestock is one event which does lead to a total loss of production data, is especially disruptive in small farm enterprises, and is more likely to occur the longer the observation period. In ILCA's survey villages in southeast Nigeria, between August 1982 and February 1983, 65% of the households had smaller flocks at the end of the period, 14% had abandoned goat keeping, and 4% lost all their animals due to mortality (Mack, et al., 1985). Although livestock productivity monitoring continued, the program decided to innoculate all the animals with TCRV to protect them against PPR. At this point, the opportunity to demonstrate or test the viability of the vaccination was lost. In Java, a similar disease problem arose and in order to guarantee continuing cooperation of producers, the livestock had to be treated, in this instance against parasites. This again led to the loss of a control group of animals. The problem of discontinuous data sets can be avoided using single visit surveys by experienced researchers who are familiar with the production system concerned. Such surveys are frequently viewed as "quick and dirty" whereas in fact they are valid alternative methods. Knipscheer (1982) has proposed a comparative method for the collection of labor data for secondary crops which he describes as "rapid" but reliable.

Many production models are assembled from farm management data covering all activities surrounding all enterprises, and data analysis is frequently based on maximizing assumptions. This method tends to obscure minor and secondary enterprises. Okali and Cassaday (1985) propose another solution to the problem of how to collect information on small minor enterprises. They are referring to women who participate in numerous activities at

various times, each activity involving a minimum investment of cash or purchased inputs, including labor. Most of the women were unable rather than unwilling to unravel their various incomes or value their consumption from each activity. In order to establish these returns, the authors propose collecting individual items of information from different data sources. Individual women will be timed doing different processing operations for instance, while price data will be collected from markets. All the information will be collated to construct a single model instead of being calculated from observations of how much time, etc., an activity costs a particular individual.

There is also a temptation when investigating small and minor enterprises to identify larger than average flocks, and to collect additional information that may not be useful, and certainly is not immediately relevant, while waiting for other infrequent events to occur. Sempeho (1984) sampled small ruminant producers in southwest Nigeria with five or more animals for his farm management survey even though owners with this number of animals represented only 20% of producers. Upton's model (Upton, 1985) dealt with these production units as they often are, consisting of single breeding females, while Van Eys (1984) used total liveweight per farm to distinguish between production units in West Java. The small size of individual enterprises is not a problem when the community, or even wider area, is the focus of interest. Some production effects are only visible at this level when small production units are involved.

All the various methodological problems can be avoided by focusing the whole research effort on large-scale and intensive production units whose sole objective is to maximize meat/milk production for instance, rather than to achieve multiple goals by integrating with and thereby enhancing the whole farm system. This solution is tempting and not necessarily problematic[6] but is based on a one-dimensional view of the importance of a product. In their specification of criteria which establishes the importance of a given enterprise, Spencer, et al. (1979), uses its contribution to total income. In their case, they consider an enterprise to be important when it forms 10% of total income.

Variability of Product and Producers

One aspect of family farming that makes it almost impossible to classify producers in a meaningful way for purposes of sampling and trials is the variability between producers in their livestock, management, type, and use of labor.

Both research programs have attempted to use differences in livestock management to discriminate between individual producing units. ILCA Ibadan used levels of feed supplementation to stratify small ruminant producers, but no relationship was established between the identified strata and small ruminant productivity and the sampling frame was dropped. Similar attempts were made in Java, but it eventually became clear in both programs that the most dramatic difference in management was between producers who confined animals--more or less--and producers who either grazed their animals or

allowed them to roam freely. In both locations, while these practices varied somewhat within a single community, differences between communities and whole areas was greater, confinement increasing as cropping intensity increased. In Nigeria, the southeast was defined generally as an area where animals were confined and comparisons were made with the southwest. In Java, the comparison was between lowland, where confinement was practiced, and upland villages. Both programs subsequently demonstrated differences in livestock productivity between their contrasting sites, again demonstrating the value of using whole communities rather than individual units for observations and trials.

Researchers traditionally deal with problems of variability by standardizing the items being observed. The way different members of the labor force are often handled provides an ideal example of the procedures used. For years, economists have attempted to standardize labor units on small farms where most labor used is that of the farm family itself. As early as 1933, Beckett (1947) used the most popular solution of converting all labor into standard "man-days" for purposes of establishing returns to cocoa production. While this exercise may have some value, its limitations must be recognized. Sex- and age-linked role division is common to family farming systems and it is important to acknowledge this division when designing innovations. Small ruminants, for instance, are often owned by women in West Africa and their labor may be the only labor available for this activity. In Java, the system of herding depends almost entirely on the labor of small boys.

For trials, the standard way of approaching variability of the product is to introduce uniform planting material or livestock breeds. This enhances the researcher's control and allows comparability between trials. Alternatively, researchers may attempt to match individual animals, although this practice is more commonly pursued on experiment stations. Producers' experiments do not necessarily share the same methodological assumptions as those of researchers. Producers may prefer the variety inherent in local planting material and livestock to the uniformity of pure line selections.

Since replicated trials are popular, it is relevant to ask what happens when individual cooperators abscond or threaten the successful termination of a trial. We must assume that problems will arise since no single design can satisfy the needs of individuals even within a single community.[7] Producers frequently balk and need incentives for the trial to continue as directed. In this situation, producers might be paid to continue as in the SR-CRSP Program, Kenya. Alternatively, scientists may attempt to enforce discipline as was the case in a trial described by Okali and Milligan (1982). When Fulani pastoralists attempted to use feed supplements other than for selected animals in their herds, the researchers increased the supervision of feed delivery. The trial involved feeding supplements of agro-industrial by-products to selected animals in Fulani cattle herds and was designed to include control animals in the same herds. It was assumed that the innovation was "developed" because scientists had elsewhere demonstrated increased milk production over and above the cost of the supplements. The pastoralists attempted to use the supplements other than for selected animals, not even simply for lactating animals being used as

controls, but also for nonlactating animals. The first reaction of the researchers was to increase the supervision of feed delivery. This occurred because the researchers wanted to measure productivity differences as well as to demonstrate the value of the intervention to the herders. It soon became clear that while this strategy might permit measurement of production, it would not demonstrate a viable technology to the herders who had multi-purpose goals. In addition, while herds might be managed by one person, the animals were owned by many individuals and managers could not show preference for one particular group of animals, which the trial design demanded. In the end, the researchers had to design a broader feeding strategy, with more attention being given to the goals of the herders themselves.

The most successful conventional on-farm trial (in the sense that the scientists were able to control the intervention and measure changes in the conventional manner) described by the programs involved the evaluation of annual TCRV vaccination to control PPR already described.

Producers' Trials

Scientists, in their eagerness to satisfy conventional methods of hypothesis testing, have burdened on-farm work and the on-farm trial design unnecessarily. In major crop-based FSR, scientists have been able to develop this methodology, especially in areas of scarce high quality land where crop yield becomes the dominant parameter. In general, on-farm livestock trials, but also small farm plots, yield data with higher than usual statistical variance (Bernsten, et al., 1983), which should encourage scientists to look for alternative sampling and evaluation measures. Both small ruminant programs have developed ways: by focusing on whole communities rather than on individual production units, and by seeking alternative evaluation measures. In Nigeria, an alternative to actual tree measurement was introduced to evaluate tree establishment: eyeball observation by more than one person at a time combined with a simple checklist. In Indonesia, regular research field hearings were introduced and these provided a forum where farmers could give feedback. Both these and other livestock programs have also been concerned to broaden on-farm research beyond trials.

At a recent ICARDA workshop on livestock-on-farm-trials (LOFT) methodology, a heated discussion erupted about the need for replications. The issue broadly divided the social scientists--who argued that replications were not essential, from the biological scientists who held the opposite view. Unfortunately, there is often a tendency to assume that the only alternatives to replications are no replications. It is clear from examples given in this paper that alternatives exist. Their use frequently requires a shift in attention from the technology or trial itself to its interaction with the wider environmental, biological, and socioeconomic systems. It also requires a shift from viewing socioeconomic interactions as constraining influences to be controlled to viewing these as factors determining the type of technology to be introduced and the trial design. Using this approach, on-farm trials are, if appropriate at all, first designed by producers, as Zandstra (1984) and Norman and Collinson (1985)

acknowledge. In the small farm context with which most FSR programs are concerned, we predict that by using this approach there will be replication by farmers of the same design and, consequently, a wealth of information will be produced about the applicability and likely impact of a new technology being developed.

Footnotes

[1] Baseline surveys and subsequent farmer involvement in technology design are discussed in Okali and Sumberg (1986).

[2] These systems have been described in numerous publications by the two research programs. The most comprehensive sources for each of these are Sumberg and Cassaday, eds. (1985) and Knipscheer, et al., (1983).

[3] Sharecropping is a system whereby borrowers of breeding stock share offspring with owners and meanwhile incur all maintenance costs. The system makes it possible for people with no stock or capital to purchase stock, to enter small ruminant production, or increase their flock size. At the same time, producers with larger flocks distribute the cost of their own labor and spread their risks.

[4] For a description of farming systems research which implicitly assumes that this is a sufficient description of on-farm research, see Simmonds (1984). For a description of an alternative view, see Okali and Sumberg (1986).

[5] For a detailed review of the issues surrounding these concepts, see Guyer (1981) and papers presented at the November 1984 workshop, "Conceptualizing the Household," held at the Harvard Institute for International Development.

[6] This approach to development is not always viewed as problematic. As has been argued by Okali and Sumberg (1986), it reflects a choice in development approach that essentially is not concerned with incremental production increases on the part of large numbers of small producers.

[7] For a description of the various ways in which 65 farmers from two communities incorporated alley cropping into their systems, see Okali and Sumberg (1985). Ay (1978) provides smaller evidence of the variety of individual farmer needs and hence the differential effect of a single development program.

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Table 1. Conventional and alternative approaches to farming systems research problems.

Problem	Conventional solutions	Alternatives
No clear production/consumption decision-making units	Define/identify a family unit	Unit defined by problem-community interacting households
Small units	Large samples/larger than average units/long-term observations/group trials	Different data sets, parallel and sequential data collection
Variable livestock/labor	Standardize units/enforce replicated trials of complicated packages	Simplify introductions/allow farmer experimentation
Minor/secondary enterprises	Large-scale technology maximizing solutions	Integration in other components of farming systems

Table 2. Comparison between locations in small ruminant production.

	Nigeria		Indonesia
	Southwest	Southeast	West Java
AREA			
Population density	medium	high	high
Farming system	extensive	intensive	intensive
Cropping intensity	medium	high	high
Farm sizes (mean)	medium	small	small
Off-farm income	high	high	medium
SMALL RUMINANTS			
S:G	1:4	1:4	2:1
As percent farm income	1-5%	1-5%	10-25%
Feed (most common supplements)	Crop by-products	Crop by-products	Crop residue and browse
Population growth	stagnant	declining	stagnant
Management level	low	medium	medium
Type of management	open grazing/ minimal confinement	medium/total confinement	total confinement in lowlands
End product	meat	meat	meat
Flock size (mean)	2-4	2-4	5-7
Mortality	high	very high	medium

Table 3. Common agricultural development paradigms and their solutions.

Constraints in existing system	Solutions
Land tenure	Privatize/registration of titles
Labor shortage/implements/techniques	Work oxen/tractors/group farming
Credit/exhorbitant interest	Project lending
Soil fertility/slash & burn/shifting cultivation	Fertilizer/permanent cropping
Individual farmer conservatism/ traditionalism	Contact farmers/extension training/integrated rural development/group farming
Research extension gap	On-farm trials/adaptive research
Varieties/breeds	Improved breeds
Traders	Institutional marketing

Source: Okali and Sumberg, 1985.

CROP/ANIMAL INTERACTIONS

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INTEGRATION OF CROPS AND ANIMALS IN ON-FARM RESEARCH IN NORTHERN NIGERIA

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INTRODUCTION

Background Information

As a result of the wide variation in the agroecological zones ranging from the mangrove fresh water swamps in the south to the Sudan and Sahel Savanna zones in the north, Nigerian agriculture is dominated by food and tree crops production. The wide variation in climate and vegetation permits the production of many subsistence crops like cassava, cocoyams, plantains, bananas, maize, guinea corn, millet, and sugar cane. The main export crops are groundnuts, cotton, beniseed, and soybeans from the north and palm produce, cocoa, and rubber from the south.

The climate also favors the rearing of livestock such as cattle, sheep, goats, poultry, horses, and donkeys. Of the estimated 8 to 9 million cattle population made up of the Zebu breed, Chaud, Kuri, and Muturu types, 80% is concentrated in the north. The unequal livestock distribution is a result of the geographical factors such as climate, topography, and the concentration of the Fulani people with whom pastoralism is associated. An important aspect of the livestock to the farming system, especially in the tse-tse fly free areas, is the possibility of using cattle for drawing carts and plows. As Nigeria faces severe food crises, new crop varieties and cultural practices developed in the research institutes are currently introduced to the farmers through the on-farm adaptive research program. New technologies inevitably create new labor bottlenecks. The use of cattle as draft animals is considered a major technology that can overcome the new labor bottlenecks arising from the introduction of improved crop practices.

The On-Farm Adaptive Research (OFAR) is the third stage of the Farming Systems Research and Extension (FSRE) process preceded by the Diagnostic Survey and the On-Station Technology Design stages. At the Diagnostic Survey stage, attempt is made to understand the agricultural problems of an area and identify the key constraints inhibiting rapid increases in production. The On-Station Technology Design stage is aimed at putting together a set of recommendations to remove constraints identified. The OFAR phase is carried out on farmers' fields to test and verify the effectiveness of recommendations proved on experimental fields to remove identified constraints.

Literature Review

For many years since the establishment of the Institute for Agricultural Research (IAR) at Samaru in 1922, greater emphasis was placed on on-station experimentation without adequate diagnosis of the problems prevailing at the farmers' level. With the inception of the Rural Economy Research Unit (RERU) in 1966, later called the Department of Agricultural

Economics and Rural Sociology, researchers in IAR began to see the need to develop technologies relevant to the farmers' conditions. For example, emphasis is gradually being placed on crop mixtures rather than sole crops alone at the experimental stations, Norman (1972) having reported that 67% of the farming land is devoted to crop mixtures. Over time, some technologies have been developed at IAR to address constraints faced by the farmers.

Attempts have been made to test the developed technologies under farmers' conditions. Norman (1974) tested the recommendations made on cotton by IAR technical researchers. A similar assessment was made on sole crop maize and sole crop sorghum under small-scale farmers' conditions (Norman, et. al., 1976a and 1976b). Ogungbile and Ogborn (1982) made an economic evaluation of herbicide use among 78 farmers in Yaba village in Malumfashi district of Kaduna State in 1975 and 1976. Similarly, Olukosi, et. al. (1982) assessed the technical and economic feasibility of improved onion and tomato technologies among Shika Dam farmers. An economic evaluation of the improved technology was conducted among Guided Change Project farmers in Giwa District of Kaduna State (Banta, et. al., 1983). On-farm technology tests are being conducted on cowpea (Chuke and Voh, 1985), on maize, sorghum, and millet (Ogungbile, et. al., 1985), on onions and tomatoes (Olukosi, et. al., 1985), and on maize/cotton, maize/sorghum, and maize/cowpea mixtures (Institute for Agricultural Research, 1985).

Problem Statement and Need for Study

Most of the above mentioned studies have one common deficiency, except one by Norman (1982) and the other by Ogungbile and Ogborn (1982). None of the others considered the use of animal power for crop production. It has been observed that in general FSR in northern Nigeria lacks adequate emphasis on the integration of crop and livestock (Abalu, 1984). The omission of the livestock subsystem arises out of the fact that national agricultural research in Nigeria is organized along separate crop and livestock lines, with each national research institute having a mandate for a prescribed number of crops or animals. Secondly, a great number of northern Nigerian farmers who grow crops do not keep cattle and vice versa. Thirdly, the possession of workbulls and managerial ability in handling them for farm work is not a common occurrence in areas where the government has not made specific intervention in the past. In order to correct the apparent disintegration between crop and livestock research at the farmers' level, the Federal Ministry of Education, Science and Technology (FMEST), in collaboration with the Australian Centre for International Agricultural Research (ACIAR), has planned to fund some projects along this line. Due to some administrative reasons, the plan is yet to be implemented.

Prior to the formulation of the FMEST/ACIAR plan, the authors have seen the need to view the crop production subsystem as being part of a larger household economic diversification strategy involving other subsystems like livestock and non-farm activities. This dual consideration affords a complete understanding of the farming system of an area. As a prerequisite to more extensive research on crop and livestock integration at the farm level, a study of this nature will help identify problems associated with

the use of oxen and those of introducing on-farm adaptive research involving livestock management.

Objectives of the Study

The objectives of this study are:

1. To describe the pattern of animal farming and labor employment in two villages.

2. To determine the technical and economic superiority or otherwise of oxen over the hoe farming system.

3. To identify problems associated with the use of oxen and that of introducing an on-farm research program.

METHODOLOGY

The Setting

Location and Environment. The study area, which is situated in the Northern Guinea Savanna zone, is located in the north of Kaduna, the Kaduna State headquarters. The two villages chosen for the study were Daudawa (11°38'N and 7°09'E) and Nasarawa (11°40'N and 7°05'E), both in the Funtua Local Government Area of Kaduna State. The area is underlain by rocks of the basement complex which is dominantly granite. The landform is a gently undulating plain at an altitude of 450 to 750 m. The area possesses leached ferrugunious soils with well-developed textural B horizons containing 30 to 40% clay. The soils are poorly drained and the upland soils contain high silt content, while the valleys contain hydromorphic soils which are of clay texture.

The mean temperature in the Daudawa-Nasarawa area rises to as much as 85°F in the months of April-May and drops to about 70°F in the months of December-January. The climate is subhumid, with a severe deficit in rainfall from October to May and surplus from June to September. There is hardly any rainfall at all between the months of November and March, as can be observed in Table 1 which shows the rainfall distribution during the years of study. Hardly any growth of vegetation can occur during this November-March period except by irrigation. The growth of a wide variety of short season annual crops is supported by the water regime. Very long season or perennial crops can only be grown under irrigation or where the water table never falls to excessive depths.

Socioeconomic Factors. Agriculture forms the principal means of livelihood for over 70% of the people in the area. Land is communally owned while individuals possess only the usufructuary rights to the piece of land they own. Farm land is claimed to be owned through inheritance, allocation, loan between individuals or families, pledge, and some cases of monetary transactions in the case of large private commercial farms. The average farm size is 9.4 ha (oxen and hand power), ranging between 0.8 and 45.0 ha.

The settled people in the Daudawa village are mostly Hausa, while those at Nasarawa are Maguzawa (Pagan Hausa). The Moslem faith is predominant among the people of the area, especially at Daudawa, while the Hausa language is spoken by both groups. There is an Agro-Service Centre in Nasarawa, although Daudawa farmers also have access to the Nasarawa centre. The major market for the area is at Shemi, which is about 5 km from Daudawa and about 10 km from Nasarawa. Being an ADP project area, the area is advantaged in terms of access to input and output markets. Apart from the commercial banks, there is a branch of the Nigeria Agricultural Bank (NACB) at Funtua, which is about 22 km away from Daudawa and 25 km away from Nasarawa.

Nature of Cropping System. The major crops grown in the study area are cereals and grain legumes, maize, sorghum, millets, groundnuts, cowpeas, and fiber crops like cotton. Most crops are grown sole or in mixtures. Cereal crops appear to be the most predominant, occupying up to 76% of the total farm holding. Maize is the major crop in the cropping system of the area, accounting for about 50% in the total cropping system, while sorghum accounts for about 25% and millet 1% (Table 2).

The remaining 24% is made up of non-cereal crops. Several combinations of the crops are found in the mixtures. The seven most important maize cropping patterns for 1983 are shown in Table 3. The most important reason for the maize cropping pattern in the area lies in the early maturing nature of maize, hence its usefulness in overcoming food shortages early in the season. The economic reason lies in the fact that maize is used to generate cash early in the season, while the risk factor lies in the fact that maize is less subjected to weather variations than most cereal crops. Total loss of maize crop is not often encountered.

Labor is supplied mostly by family members and supplemented by hired labor for certain operations. Males contribute about 73% of total labor while females contribute about 20% and the remaining 7% by children between 6 and 14 years of age. The source of farm power in the study area is mainly human and oxen, with very little tractorization. Cash requirement by the farmers reaches its peak during the peak farming season for carrying out weeding operations. A few of the farmers own cattle and workbulls, while almost every farming household keeps some form of other types of livestock like sheep, goats, and poultry.

Constraints Identified

Baseline studies were conducted to identify the production problems in the area of study. Given the hoe system of farming, the drudgery involved in land preparation limits, among other things, the cropped land area. Labor was found to be constraining during the June-August weeding period. Yield was observed to be low using the traditional technology, especially for the two most important crops of the area, maize and sorghum. The diagnostic or problem identification phase was designed to be a continuous component of this study to afford a complete evaluation of the changes taking place as a result of farmers' adoption of the new technology.

Technology Design

In order to remove the identified constraints, sole crop maize and sorghum technological packages already designed, tested, and proved to be promising at the Samaru Institute for Agricultural Research, experimental fields were used for the on-farm tests in the study area under hoe and oxen farming systems. Improved maize/sorghum crops mixture technological packages could not be used because they were not ready at the commencement of this study.

The technological packages tested were:

1) Maize:

a) Fertilizer: Broadcasting of single superphosphate (SSP) at 250 kg ha^{-1} on old furrows before ridging. Application of calcium ammonium nitrate (CAN) at 250 kg ha^{-1} at 2 to 3 weeks after planting, followed by another application of CAN at 250 kg ha^{-1} 8 weeks after planting.

b) Plant Arrangement and Spacing: In order to obtain a target population of 50,000 plants ha^{-1}, seeds should be sown at 25 cm apart on ridges spaced 75 cm apart. Seeds were to be sown when the rains are well established, preferably the first 10 days in June. Seeds are to be sown 2 to 3 per hole and thinned to one plant per stand 2 to 3 weeks after planting.

c) Weed Control: Application of preemergence herbicide (premagram) on well prepared seedbeds immediately after sowing, at 4 liters ha^{-1}.

d) Variety: White color and high yield TZB maize variety.

2) Sorghum:

a) Fertilizer: Broadcasting of 250 kg ha^{-1} of SSP fertilizer on old furrows before ridging. Application of 125 kg ha^{-1} CAN two weeks after sowing and 125 kg ha^{-1} at 8 weeks after planting.

b) Plant Arrangement and Spacing: As for maize.

c) Weed Control: Application of preemergence herbicide (sorgoprim) at 3 liters ha^{-1}, immediately after sowing.

d) Variety: The planting of the yellow grain colored, high yielding striga resistant, and long-term maturing L.187 sorghum variety. The yield is expected to be about 2.6 tons ha^{-1}.

Choice of Villages

The use of animal traction, which is a more advanced method of cultivation, is not as common as the use of the traditional hand hoe.

Daudawa village was chosen because it is the nearest and most easily accessible village to the Research Station in Samaru with a sizeable number of farmers using oxen. Nasarawa village, located about 4 km from Daudawa, was chosen because the farmers there predominantly use hand tools only.

Sample Size

From a list of farmers in each village, a total of 68 farmers consisting of 46 oxen farmers and 22 hoe farmers were selected at random. This sample size was based on available resources. All the 22 hoe farmers were selected from Nasarawa, in addition to 11 oxen farmers. A total of 35 oxen farmers were selected from Daudawa. Thus, the number of farmers involved in testing the packages is a total of 29 composed of 9 hoe and 20 oxen farmers for sorghum, and 39 farmers comprising 13 hoe and 26 oxen farmers for maize. Table 4 shows the distribution of the sample among crops and technologies.

Plot Size

Because of limited resources and the large number of farmers to be included, each participating farmer was encouraged to grow sorghum or maize. A 0.4 ha plot, which was further divided into two equal subplots, was measured from each of the participants' farms. Each subplot was either treated with herbicide or subjected to traditional hoe weeding as practiced by the farmer. The time taken to complete each cultural operation was recorded throughout the production period with the aid of enumerators stationed in the villages. Supplementary hoe weeding was permitted on herbicide treated plots if and when necessary.

Data Collection

The study period has stretched between four production periods, 1981 to 1984, although only the first three years of data are reported here. The trial was both farmer and researcher-managed in 1981 when the herbicide was applied by the research staff in the presence of the farmers. As of 1982, the herbicides were applied by the farmers on their own, under the supervision of the research staff. During the first two years, 1981 and 1982, the inputs were supplied free, but in 1983 farmers were asked to pay for the inputs after harvest. The 1984 season was considered a monitoring and evaluation year in which the plots were not measured as in previous years. Observations were made to see how the farmers modified the technologies in trying to incorporate them into their systems.

Farmers' perception of the technologies were also determined and additional information was gathered in 1985 among 52 farmers in the two villages comprised of 26 cattle owners and 26 non-cattle owners. The aim of this one shot survey was to determine the extent of and the problems associated with the on-farm integration of crops and livestock in the study area.

RESULTS AND DISCUSSION

Socio-Demographic Characteristics of Sampled Farmers

Table 5 shows that the average age of the oxen farmers is 47, while those of the hoe farmers is 35 years. The cultivated land area per person is much lower among hoe farmers than oxen farmers. This shows that the younger farmers are running the smaller farm units. About 62 and 50% of the oxen and hoe farmers respectively claimed to be literate, at least in the local vernacular or Arabic.

Land Use

Cereal crops are the dominant crops in the area, occupying about 70% of the total cultivated area in 1981 and rising to about 76% in 1983. Maize was found to be the most dominant crop, occupying over 40% of the total area under cultivation. Small and medium scale farmers still grow sorghum on a larger proportion of the cultivated area, hence sorghum occupies about 30% of the total area under cultivation. As expected, the proportion of land put to maize production is about 70% of the total cereal production in the study area.

Labor Use

Average monthly labor distribution in maize and sorghum production for 1983 is shown in Table 6. The weeding labor requirements in maize and sorghum production are shown in Table 7. The figures show that the herbicide used has reduced the maize weeding time by 61% under oxen cultivation. Sorghum weeding time has been reduced by 50 and 56% under hoe and oxen systems respectively. This indicates that herbicide use could be more effective in controlling weeds on land prepared by animal traction than by hoe. Hence, land preparation may be a useful complement of the improved technological package in terms of labor saving. Table 8 shows the labor requirements by operation. Ridging requires about 59 to 94 manhours per hectare by hoe and only 14 to 20 manhours by oxen under both crops. The use of oxen for land preparation is labor saving and greater land areas can be covered.

The increase in harvest accompanying the oxen plus herbicide technologies shift the labor bottleneck from weeding to the harvesting period, especially for maize where a substantial increase in yield is obtained.

Yield

The average yield figures (Table 9) show that for maize better yields are obtained under oxen than under hoe cultivation, whereas the reverse occurred for sorghum. For both crops and both technologies, the yield appears to be higher under herbicide use. In general, the improved sole crop technologies (test plots) far outyield farmers' traditional technology, as can be seen in Table 10.

Returns

The costs and returns per hectare are shown in Tables 10, 11, and 12. Despite the higher costs involved as a result of the new technologies, the increase in returns more than offset the costs. The return to labor (N$ manhour^{-1}) is 30% greater on the test plots than farmers' plots and 84% greater in terms of return to land (Table 10). For maize production, the return per hectare is greatest when herbicide is applied on oxen prepared farms. For sorghum production, however, when land is prepared by oxen it appears less profitable to apply herbicide, unlike under hoe cultivation. The total cost per hectare of producing maize, irrespective of oxen or hoe system, is about the same. This is because, apart from the ridging operation, hand labor is used for all subsequent operations, including harvesting. The same trend is observed for sorghum. The farmers were able to generate some marketable surplus. The percentage of total output of maize in 1983 was 59 while that of sorghum was 32.

Farmers' Evaluation of the Technology

About 65% of the farmers claimed that the experimental plots required higher labor inputs than the traditional farmers' plots. About 60% of the farmers agreed that the use of herbicide saved a lot of labor, while 30% said it only saved fairly enough labor on weeding. About 60% of them said that the experimental plots were more difficult to manage but that they are more profitable in the long run.

The farmers were supposed to incorporate the fertilizer into the soil. About 80% of the farmers claimed that this was labor intensive, hence they preferred placing the fertilizer beside the plants and allowing the rains to dissolve it into the soil. This method, however, results in waste because a good part of the fertilizer is washed away by rain water, making it unavailable to the plants. Secondly, the recommended split application of CAN was not followed because of pressure of work from other fields. They applied CAN only once at about 3 to 4 weeks after planting.

The recommended spacing (.75 x .25m) was considered too close and time consuming for manual operation. A wider spacing (0.9 to 1.0 x 0.3m) with two plants per stand was adopted. The ridges of those using workbulls were generally 90cm apart and 1m for those using hand hoes. Considerable progress was made between 1981 and 1983 in persuading the farmers to observe closer spacing. About 30% of the farmers slightly exceeded the target population of 50,000 plants ha^{-1}. Over 80% had plant density exceeding 40,000 plants ha^{-1} in 1983 as against 50% who did in 1982.

Supplementary weeding was still required in some of the herbicide treated plots, which was in most cases due to poor land preparation. About 50% of the sampled farmers using animal traction did not have to weed at all. Between 1981 and 1983, the amount of supplementary weeding needed to be done has been cut down from 50% to about 30% for hoe farmers and from 40% to less than 20% for oxen farmers. The majority of the farmers were satisfied with the yield performance except for the year 1983 when the rainfall badly affected sorghum yield.

Problems of Integrating Crop and Livestock Farming

Animal power system was introduced by the British colonial administrators in the early 1920s with two objectives in mind. First, they wanted to obtain cash crops such as groundnuts and cotton grown in the northern part of the country in sufficiently large quantities for the British home market but discovered that there were limitations imposed by the available traditional production techniques. Second, they wanted to improve the peasant farmer's conditions and raise his income. A new farming system called "mixed farming" was evolved so that a farmer could increase the farm area by the use of a bullock-drawn plow and at the same time maintain that area in a high state of fertility with manure from the bullock. The system required farmers feed their livestock with crop residue from the farm and also grow supplementary pasture so that they did not have to resort to what the colonial policy regarded as "trespassing in other people's land in search for food." The farmers were expected to raise their standard of living by increasing the productivity of labor and crop production (Musa, 1983). Between 1928 and 1933 mixed farming was introduced in Kano, Sokoto, Bauchi, Kaduna, and Borno States. From 1928 to 1955 an accurate record of those who were trained as mixed farmers were kept and given mixed farming package on credit.

At present, government attitude to oxenization seems to be one of indifference. Oxen mechanization initiative is to a large extent left in the hands of the peasant farmers. At independence, the defunct North Regional Government inherited the promotion of mixed farming system and the drive to establish a farm institute for training primary school leavers to adopt mixed farming with the collaboration of USAID. Records do show that the government maintained the momentum up to 1967 when states were created.

From 1967 to date, government interest in promoting animal mechanization has been in policy papers only. No farm center in the ten northern states maintained a mixed farming training scheme. Farm Centres no longer coordinated a loan scheme for ox-farming, or stocked ox-drawn implements for sale to farmers. The College of Agriculture, Samaru, has completely phased out the mixed farming course and animal draft power training in its curriculum. No department of agricultural mechanization offers practical training in animal mechanization which could be the source of relevant expertise to help promote the efficient use of animal draft power.

The only reminiscence of government interest in animal mechanization was in the annual State's agricultural shows and the World Bank-supported Agricultural Development Projects (ADP). The ADPs at Gusau, Funtua, and Gombe and the Kano State Integrated Rural Development Project (KSIRDP) encourage oxenization by giving some loans and stocking the implements and spare parts for farmers to buy.

All 52 farmers interviewed in the one shot survey kept some form of livestock or another, like goats, sheep, and chickens, which are allowed to roam around. There is little or no intensive care of these animals. The livestock owners on the average claimed they sold about N$453 worth of

cattle and cattle products, N$96 worth of sheep, N$111 worth of goats, and N$10 worth of chickens. The non-livestock farmers claimed to have sold N$120 worth of sheep, N$65 worth of goats, and N$10 worth of chickens and, of course, no cattle. Both groups used donkeys to transport between 25 and 75% of their cereal farm output from the fields.

The cattle owners claimed that they had no problem feeding their cattle during the raining season. Considerable problems, however, are encountered during the dry season. Their major problem is that of training their workbulls, for which there is no government assistance. The non-cattle owners are reluctant in keeping cattle because they claim that they do not possess the skills in dealing with cattle but realize that with government assistance they could improve upon the management of small ruminants.

The major problems identified are summarized as follows:

1) Lack of managerial skills in handling large animals.

2) Problems of availability and maintenance of implements like plows, ridgers, shares, and yokes.

3) Harvesting equipment to handle increased harvest which still has to be carried out manually.

4) Lack of supporting services required for successful integrated crop and livestock farming such as credit, extension service, livestock service to vaccinate animals, and supply of equipment (for spares and repairs).

5) There is a general lack of a well established system of on-farm adaptive research.

6) Lack of marketing system which enables farmers to sell their surplus producion.

CONCLUSION

The results of the on-farm evaluation of maize and sorghum technology packages appear to be profitable under both hoe and oxen farming systems. Oxen traction was found to be both technically and economically superior to hoe farming systems. It was observed that although oxen considerably reduced the labor requirement for land preparation, it was not used for other subsequent operations which were carried out manually. Land preparation alone does not bring maximum benefit. Complete packages, including weeding and harvesting, are needed to cure the increased labor and harvesting labor requirements due to increased output.

It is recommended that a viable integrated crop and livestock on-farm adaptive research be developed. Farmers' reluctance in keeping cattle can hinder introduction of such on-farm adaptive research programs. It is essential that extension and training be strengthened to overcome this

hindrance. The lack of supporting services, including credit, veterinary services, and equipment supply and maintenance, must also be remedied. At least a 10 to 20 year time horizon is needed for institutionalizing an on-farm adaptive research program involving crop and livestock management.

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Table 1

Rainfall distribution in Daudawa (11°38'N and 7°09'E) 1981 to 1983 in millimeters.

Year	Months												Annual fall
	J	F	M	A	M	J	J	A	S	O	N	D	
1973*	-	-	-	17	35	74	91	230	124	24	-	-	594
1981	-	-	-	107	84	152	174	320	216	1	-	-	1053
1982	-	-	-	26	36	94	124	210	104	85	-	-	679
1983	-	-	-	-	64	99	143	255	127	-	-	-	688

Source: Rainfall Record at Daudawa Farm Service Centre, 1981 to 1983.

* Adapted from Ogungbile (1984).

Table 2

Area devoted to each crop as percent of total.

Farm Strata	Millet		Sorghum		Maize		Cotton		Groundnut		Cowpea		Others	
	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982
1	-	-	40.0	60.6	25.7	27.3	24.3	12.1	5.7	-	4.3	-	-	-
2	3.5	1.1	46.4	38.8	30.0	38.0	14.8	16.8	3.0	-	1.8	4.7	0.5	0.6
3	7.9	2.4	39.0	22.6	41.5	32.3	4.3	34.3	2.7	2.7	4.6	3.3	-	2.1
4	3.3	4.4	28.3	34.5	24.9	28.3	35.9	28.3	4.3	0.9	2.8	1.8	0.5	1.2
5	0.2	-	21.0	21.2	55.5	60.3	20.0	16.9	1.2	0.4	0.7	0.7	0.4	0.0
Total	1.3	0.7	25.5	24.5	48.9	53.2	20.0	19.1	1.8	0.5	1.4	1.3	1.1	0.0
Overall Average		1981	75.7%				Total	Total non-cereals		1981; 24.3%		1982; 21.6%		

Table 3

Maize cropping patterns in Daudawa, 1983.

Cropping Pattern	Actual area cultivated (ha)	Area cultivated as a percentage of the total maize hectarage
Sole cropping	141.6	72.32
Maize/sorghum	35.4	18.08
Maize/cotton	5.2	2.66
Maize/cotton/cowpea	2.4	1.23
Maize/sorghum/groundnut	5.6	2.86
Maize/sorghum/cowpea	0.4	0.20
Maize/cowpea/sweet potatoes	5.2	2.66

Source: Survey data, 1983.

Table 4

Distribution of the sample between the sorghum and maize crops and the two types of technologies.

	Sorghum			Maize			Total Sample		
Village	Oxen	Hoe	Total	Oxen	Hoe	Total	Oxen	Hoe	Total
Daudawa	15	--	15	20	--	20	35	--	35
Nasarawa	5	9	14	6	13	19	11	22	33
Total	20	9	29	26	13	39	46	22	68

Table 5

Summary characteristics of oxen and hoe farmers in Daudawa and Nasarawa, 1981-85.

	Oxen farmers	Hoe farmers	Total sample
Number of households in sample	46	22	68
Persons per household	9.08	5.42	7.25
Adult workers/household	5.12	4.62	4.87
Total area cultivated (ha)	514.80	77.40	592.20
Total area cultivated/person	1.23	0.65	1.20
Value of oxen owned	1,280	0	1,280
Age of farmer	47	35	41
Percent literacy	62	50	57

Table 6

Average monthly labor distribution in maize and sorghum production in manhours ha^{-1} (1983).

Month	Maize				Sorghum			
	Oxen		Hoe		Oxen		Hoe	
	Herb.	Without	Herb.	Without	Herb.	Without	Herb.	Without
Jan.	-	-	-	-	-		-	-
Feb.	-	-	-	-			-	-
Mar.	-	-	-	-			-	-
Apr.	-	-	-	-			-	-
May	-	-	5	4	1	-	-	2
June	31	29	115	65	47	29	20	46
July	37	89	20	125	42	89	33	116
Aug.	18	16	42	65	18	28	10	49
Sept.	-	-	35	27	8	6	44	86
Oct.	67	67	51	29	4	-	-	-
Nov.	189	216	104	140	6	17	25	10
Dec.	-	-	-	-	115	137	134	105
Total	342	417	372	455	241	306	266	414

Table 7

Weeding labor requirements in maize and sorghum production in manhours ha^{-1} (1983).

Crop	Mode of Cultivation	Year	Weeding time (manhours ha^{-1}) Herbicide	Without	% Labor saved
Maize	Hoe	1981	na	na	-
		1982	41	83	51
		1983	20	74	68
		Average	31	79	61
	Oxen	1981	37	96	60
		1982	23	69	67
		1983	7	59	88
		Average	22	75	71
Sorghum	Hoe	1981	na	na	-
		1982	61	139	56
		1983	na	105	-
		Average	61	122	50
	Oxen	1981	56	126	56
		1982	33	88	63
		1983	38	74	49
		Average	42	96	56

Source: Survey Data.

na = not available.

Table 8

Labor requirements in manhours per hectare by operation for maize and sorghum, 1983.

Operation	MAIZE				SORGHUM			
	Hoe		Oxen		Hoe		Oxen	
	Herb.	Without	Herb.	Without	Herb.	Without	Herb.	Without
Ridging	70	59	16	15	90	94	14	20
Fertilizer Application	15	17	23	23	13	11	23	19
Planting	48	46	34	33	57	53	31	36
Herbicide Application	4	--	3	--	4	--	5	--
Thinning	--	--	1	1	5	12	10	6
Weeding	23	63	19	72	61	139	30	112
Re-ridging	52	70	12	13	77	107	10	12
Total pre-harvest	212	255	108	156	307	416	122	205
Harvesting	215	145	240	250	211	189	123	84
Total	427	400	348	406	520	605	245	289

Source: Survey Data

Table 9

Average yield of maize and sorghum in kg ha^{-1} (1981-1983).

Crop	Mode of Cultivation	Year	Yield kg ha^{-1} Herbicide	Without
		1981	na	na
		1982	2401	1624
	Hoe	1983	2632	2400
		Average	2517	2012
Maize				
		1981	2540	2247
		1982	3138	3037
	Oxen	1983	2957	2729
		Average	3048	2883
		1981	na	na
		1982	1844	1745
	Hoe	1983	1596	1491
		Average	1720	1618
Sorghum				
		1981	1093	2141
		1982	1715	1560
	Oxen	1983	1658	1588
		Average	1488	1463

Source: Survey Data

Table 10

Yields, costs and returns of maize and sorghum production under farmers' traditional plots and test plots.

Items		SORGHUM			MAIZE		
		Farmers'	Test	% of difference	Farmers'	Test	% of difference
Yield kg ha^{-1}	1981	734	914	25	988	2394	142
	1982	609	1620	166	898	2929	226
	1983	544	801	47*	1287	2559	99
Variable Cost N$ ha^{-1}	1983	18.64	62.42	+235	48.54	141.49	+191
Labor man-hour ha^{-1}	1983	356	531	+49	544	848	+56
Return to labor N$ $manhour^{-1}$	1983	0.53	0.45	-15*	0.80	1.04	+30
Net return N$ ha^{-1}	1983	189	241	+28	479	882	+84

*Rainfall badly affected sorghum yield.

Table 11

Costs and returns per hectare of maize (1983).

Item	OXEN		HOE	
	Herbicide	Without	Herbicide	Without
Output (kg ha^{-1})	2957	2729	2632	2400
Gross Value (N$)	1034.95	955.15	921.20	840
Input Costs (N$):				
Seeds	12	12	12	12
Fertilizer	40	40	40	40
Herbicide	69	--	69	--
Depreciation	60	60	15	15
Labor (Hired)	195	246.75	215.25	256.50
Labor (All)	225.75	314.25	279	341.25
Total cost (hired labor only)	376	358.75	351.25	323.50
Total cost (+ all labor)	406.75	426.25	415	408.25
Returns (costing hired labor)	658.95	596.40	569.95	516.50
Returns (costing all labor) N$	628.20	528.90	506.20	431.75
Yield required to cover costs kg ha^{-1}	1162	1217	1186	1166

Maize grain valued at N$ 0.35 kg^{-1}, 1983 prices.

Labor valued at N$ 0.75 $hour^{-1}$, 1983 prices.

Table 12

Costs and returns per hectare of sorghum (1983).

Item	O X E N		H O E	
	Herbicide	Without	Herbicide	Without
Output kg ha^{-1}	1658	1688	1596	1491
Gross value (N$)	580.30	590.80	558.60	521.85
Input costs (N$):				
Seeds	12	12	12	12
Fertilizer	25	25	25	25
Herbicide	60	--	60	--
Depreciation	60	60	15	15
Labor (hired only) N$	98.25	133.50	110.50	142.50
Labor (All) N$	198.75	229.50	199.50	310.50
Total cost (+ hired labor only) N$	255.25	230.50	222.50	194.50
Total cost (+ all labor) N$	355.75	326.50	311.50	362.50
Returns (costing hired labor) N$	325.05	360.30	336.10	327.35
Returns (costing all labor) N$	224.55	264.30	247.10	159.35
Yield required to cover costs (kg)	1016	932	890	1036

Maize valued at N$ 0.35 kg^{-1}, 1983 prices.

Labor valued at N$ 0.75 $hour^{-1}$, 1983 prices.

DRAUGHT ANIMAL MANAGEMENT AND EARLY PLOUGHING

B. Koch, S. Masikara, G. Heinrich and W. Matlho

Introduction

The Agricultural Technology Improvement Project (ATIP), Botswana, is a five year project. The purpose is to define obstacles to farm productivity in a whole farm context and to devise appropriate innovations to increase production. In Tutume district, the population consists largely of subsistance farmers. The project concentrates on crop production.

During the first two years of project activity in Tutume district, research efforts focused primarily on descriptive and diagnostic studies. Because of the short duration of the project (4 years in Tutume district) and the shortage of any previous agricultural research in the district, it was necessary to immediately begin examination of potential technical solutions to known problems. The assumption was that after identifying techniques to address known problems, and collecting detailed descriptive data on local farming systems, a reasonable attempt could then be made to adapt the technical innovations to fit within farmer constraints.

The average annual rainfall in Tutume district, Botswana, is 400 to 600 mm the rain typically falls over a period of four to six months. Thus, the low and erratic rainfall is a major constraint to crop production, and rainfall conservation is a prerequisite to increasing crop productivity.

Experiment station researchers in Botswana have shown that late fall plowing (after harvest) or early spring plowing (after the first rain) is a dependable and economical way to conserve rainfall in the soil (DLFRS, 1984). A system of fall plowing and spring plowing followed by row planting, has been recommended in Botswana for a number of years. However, adoption is less than 5% in Tutume district (ATIP, 1984).

Field observations in 1983-84 suggested considerable resistance among farmers to early spring plowing. The most commonly stated problem was that draft animals were out of condition at the end of the dry season. There is evidence that animal condition may be a serious problem (ILCA, 1983) especially following drought years when dry season grazing is scarce. There appeared to be other problems as well, such as: (1) difficulty in locating free roaming animals, (2) training them to the plow, and (3) taking the animals to water every day when they were kept near the home.

Agronomic difficulties with the recommended system seemed mostly to arise from lack of management skills in the maintenance and use of row planters, and the difficulty of row planting with poorly trained animals. (More than 90% of the farmers in Tutume district use a broadcast/plow planting method).

There was some evidence from trials data in 1983-84 that a system of early spring plowing followed by broadcast planting and reploughing after a good rain (double plowing) could increase yields. This method also eliminated the extra operation and associated difficulties of row planting. The system was given a preliminary test in the 1984-85 season.

The specific objectives of this test were to determine; (a) whether farmers could and would do early plowing if their animals showed adequate condition; and (b) whether double plowing would provide sufficient grain yield benefit to justify further efforts on modifying the system to fit farmer constraints. Earlier research

studies in Botswana (EFSAIP I and II, 1984) summarized many of the problems involved with dry season feeding of farm animals and suggested possible successful interventions.

METHODS AND MATERIALS

Towards the end of the 1984 dry season ATIP researchers arranged to furnish supplemental feed for some draft animals in three villages under study. In each village, one donkey farmer and one oxen farmer received supplemental feed. Supplemental feed included hay and a mineral mix made up of 50% salt and 50% dicalcium phosphate. The grass hay was purchased from the Livestock Advisory Center in Francistown for Pula 75.00 per ton (Pula 1.50 for a 20 kg bale). The hay (native grass species growing in the area) had been baled in April and May in the Pandamatenga area. Chemical analysis showed a crude protein content near 4%, crude fiber near 29%, phosphorus near 0.1% and calcium near 0.4%.

It should be understood that in this case, baled hay was used as a substitute in place of fodder or crop stover. Baled hay was considered impractical from the outset, because of cost and transportation difficulties. However, as the study was designed after post-season data analysis, it was too late to cut stover. Further, following a drought year, grazing was scarce and some supplemental feed was required to improve draft animal condition before plowing. Hence, purchased hay was used so that the study could proceed.

Feeding began in the week of August 20 and continued through the first week in November. A one week supply was delivered to each farmer once every week. Donkey farmers were told to feed one bale per day to their animals (number of animals varied from 4 to 6). Oxen farmers were told to feed 2 bales per day to their animals (number of animals varied from 5 to 11). Accuracy of feeding was sacrificed in favor of simplicity. After the first week most of the farmers appeared to be feeding the scheduled amounts.

Each donkey farmer received 77 bales (1.54 tons) which cost Pula 115.50 and each oxen farmer received 154 bales (3.08 tons) which cost Pula 231.00.

Participating farmers were told to plow an area of 50 m x 60 m (without planting) at the onset of rains. Half of that area (25 m x 60 m) received 20 kg of P_2O_5 with the first plowing. Thereafter, farmers were asked to broadcast seed and plow a 10 m x 75 m strip across the experimental area after each rainfall that exceeded 10 mm. Each strip then was 10 m wide and included a 25 m length that was early plowed and fertilized, a 25 m length that was early ploughed but without fertilizer, and a 25 m length not early plowed or fertilized (traditional check). The area involved allowed farmers to plant a strip after each of six rains. Farmers chose to plant either sorghum (Segaolane variety) or millet (Serere 6A variety). Planting dates are given by village and draft power source in Table 1.

Analysis of variance (ANOVA) was made of the stand count and grain yield data by village over all villages using an Apple IIe computer and Daisy Professional statistical package.

Data Collection

Stand counts were made by counting the number of plants within a 2 m x 2 m quadrate area. Ten quadrate areas were counted for each 10 x 25 m subplot within a planting date strip. The means of the quadrate counts were multiplied by 2,500 to obtain estimates of plants per hectare.

To obtain grain yields, each subplot in each planting date strip was harvested, dried and threshed separately. The work was done by the farmer under close supervision by ATIP personnel. After drying and threshing, the grain was weighed and yields converted to a per hectare basis for analysis.

No attempt was made to measure animal power output or to quantify any improvement in animal output. The important question was whether farmers could and would do early plowing if they thought their animals were in reasonable condition and whether that plowing would lead to potential yield benefits.

Results

All of the farmers did some early plowing before the end of the first week in November and it is important to note that all farmers plowed with their own draft animals. The first plowing was done in late September after a light rain on September 15-16.

Not all farmers managed to plant all six of the planned strips. This was due to insufficient number of planting rains, farmer absence at rainy periods or lack of researcher supervision at the appropriate times. At least 6 planting date x treatment comparisons were obtained in each village. Results of stand counts and grain yield measurements are given for each planting date comparison in Table 1.

Farmers number 620179 and 621364 (Table 1) are located in Mathangwane village. That area suffered a heavy infestation of grasshoppers during the seedling emergence period (Nov. - Dec.) which seriously affected stand densities. As a result, farmer number 620179 replanted his first three plots on day 125 (Table 1). The three plots were allocated zero yield and subsequently treated as one planting date comparison. Yields in Mathangwane were further damaged by an early end to the rains. The last rain in Mathangwane fell on day 169 (February 16). In most of the experimental plots, grain crops were without rain for the last 40 to 60 days of their growth cycle (the panicle development and grain filling stages).

Rainfall was somewhat more favorable in the two other villages, though even there, the rains ended early. The last rain in those two areas fell in mid-March (around day 195).

Farmer number 630085 (Marapong) planted on dates 080 and 087. She harvested within treatments, but across planting dates. Because the planting dates were so close together, and there were no obvious differences between the two plots, the harvests were treated as single plot yields (Table 1).

Analysis of variance for grain yields from Matobo and Marapong showed significant treatment effects. Mean grain yields for treatments, within and across villages, are given in Table 2. No significant differences in grain yield were detected in Mathangwane village probably because of the insect and drought problem which occurred there.

It should be noted that since 1948, national average sorghum yields in Botswana have been around 300 $kgha^{-1}$. Annual averages have ranged from 50 to 450 $kgha^{-1}$ (Lightfoot, 1981). By those standards the mean yields of traditional treatments in Matobo and Marapong (Table 2) are actually high, and in Mathangwane traditional yields are unusually low.

Means from the whole set (Table 2) show that early plowing followed by broadcasting and reploughing increased grain yield by an average of 262 $kgha^{-1}$ or almost 90%. This was impressive, given that the data included that from one location with very poor rains, and from others where planting was intentionally delayed after plowing and much regrowth of weeds occurred.

Discussion

From our observations in this 1984-85 cropping season we believe that we can increase the average yield gain achieved with this system. The main approach to this would be through better control of the interval between plowing and planting (which would reduce weed growth). Our principle conclusion from this years' work is that a system of double plowing and broadcast planting holds excellent potential for increasing crop yields in Tutume district. However, we do not feel that we have a system that is ready for extension. Several issues must be dealt with first.

First, is the question of how to procure and supply fodder to the animals. Buying sufficient fodder is very expensive, relative to most farm incomes. Under the parameters of this study the cost of roughage alone was P115.50 for each donkey farmer and P231.00 for each cattle farmer. Using means from the overall ANOVA (Table 2) double plowing, without fertilizer increased grain yields 262 $kgha^{-1}$. At P20.00 per 70 kg bag of grain, that increase converts to approximately P75.00 per ha. No measurements were made but the increase in grain produced certainly increased forage yield by a considerable amount, as well. Thus, it is possible that the production increase could cover the cost of buying the supplemental roughage. In this particular trial using actual roughage cost may be unfair as this was the only source of roughage in the area at the time when it was needed. Proper planning and careful conservation and usage of roughage available could surely reduce cost in future growing seasons.

Finding fodder and arranging for transport and storage would represent another major obstacle to subsistence farmers, most of whom do not even own an ox cart. The option of getting farmers to harvest their crop residues for animal feed was tried in this 1984-85 cropping season. Farmers involved in the experiments were asked to do that. None of them did so. Whether this was because they felt the benefit was not great enough, that the benefit was not well established, or the request came during a peak labor period, we do not know. But farmers did show considerable resistance even to harvesting some specific fodder crops. (ATIP, 1985). The idea of harvesting and preserving forage for later use by specific animals during the dry season seems to be a completely new idea amongst the "limited resource" farmers. The same can be said about the idea of planting certain crops specifically for use as fodder.

A second issue is whether or not supplemental feeding and early plowing are absolutely necessary in order to obtain the benefits of double plowing. One farmer who received supplemental forage for his donkeys did do early plowing with them. However, at the same time he did early plowing with his oxen. The oxen had not received supplemental forage. Thus, it would appear that a limited amount of early plowing could be done without supplemental feeding under some circumstances.

Other possible strategies are: (1) hire tractor power to do the early plowing (cost is approximately P40.00 per ha) and do the broadcast seeding and plowing after draft animals have access to new season grazing or (2) initiate the double plowing system after new season grazing is available to the animals. Beneficial effects from double plowing were observed in one experiment in 1983-84 (ATIP, 1984) where first plowing was on December 9, well after first rains, and planting plus second plowing was on January 11.

Other issues are socio economic. One might assume that if a single extra plowing can double grain yields, the practice would be profitable. But, we do lack

the economic data to make proper comparisons. Using data collected, one can make some simple comparisons as follows:

1. Minimum grain price = 20 Pula 70^{-1} kg bag.
   average additional grain production = $\frac{262}{70} \times 20 = P74.85\ ha^{-1}$

2. Government wages in rural areas for manual labor = P2.65 day^{-1}.

   Therefore, the added benefit per hectare

   $= \frac{P76.85\ ha^{-1}}{P\ 2.65\ day^{-1}} = 28.75$ days of labor per hectare or
   The benefit is equivalent to 226 hours of government labor per hectare (28.25 x 8 = 226.0)

3. To plow one hectare requires 18.6 hrs for cattle or 24.7 hrs for donkeys. (Average taken from ATIP Annual Report No. 3) Thus the single additional plowing, on average, appears very profitable.

This return figure is misleading because of two reasons: (1) there is an opportunity cost for the second plowing in that the farmer must forgo plowing new ground. This opportunity cost could be minimized by doing the initial plowing at non-optimal times when the soil was too dry for planting.
(2) There is the labor cost of fodder production and storage. Supplemental feeding was used in this study to allow very early plowing. A similar benefit might be achieved by doing the initial plowing as soon as the animals had regained condition from new grass growth. Or perhaps following years of good grass growth, early plowing might be possible without supplemental feeding. these issues need to be examined.

There is also the risk factor to consider. The extra plowing represents an added labor investment per hectare. Further data will be required to determine whether the double plowing system is more or less stable than the traditional practice and to estimate the cost of failure. However, there is a considerable range among farmers, locally, in their capacity for risk.

Another issue arises because approximately 60% of farmers in Tutume district borrow or hire draft animals or teams for plowing. In order to make policy decisions, it would be necessary to try and predict the effects of a double plow system on the availability and price of draft animals for hire, if a double plow system were to be adopted across the district.

In summary, the test did demonstrate that farmers could and would do early plowing if their draft animals were in condition. It also demonstrated considerable potential for such a system to increase crop productivity under the climatic conditions that prevailed in the 1984-85 crop year.

Simultaneously, the test raised several issues that would have to be addressed before a practical double plowing system could be recommended to farmers. These issues cover several disciplines including agronomy, animal husbandry, and socio economics. It is likely that cooperation between scientists across such disciplines would be very important in many semi-arid areas where draft animals are used, and where tillage operations can play a vital role in water conservation.

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Table 1. STAND COUNTS AND GRAIN YIELDS BY PLOT FOR INDIVIDUAL FARMERS. DRAFT MANAGEMENT TRIAL, FRANCISTOWN, 1984-85.

				Treatment***			Treatment***		
Farmer*	Crop	Plow date**	Plant date**	Stand count (plants ha^{-1})			Yield (kg ha^{-1})		
				1	2	3	1	2	3
620179	Sorghum	026	080	4,375	7,920	5,420	0	0	0
D			084	3,125	5,210	5,625	0	0	0
			094	1,670	1,670	1,460	0	0	0
			123	3,125	7,810	9,530	57	13	33
			125	M	M	M	77	79	91
621364	Sorghum	026	095	2,300	14,000	7,700	256	572	504
C			115	2,700	5,600	4,000	0	156	168
			129	16,500	18,200	17,600	127	133	307
610681	Sorghum	025	088	4,400	62,300	51,300	544	1,260	1,084
D			094	12,000	20,000	18,000	848	1,696	1,012
610099	Sorghum	067	087	13,300	12,700	18,100	360	524	856
C			094	4,000	14,300	7,300	332	564	880
			135	43,300	31,800	37,500	349	560	467
			164	M	M	M	280	464	480
630085	Sorghum	064	080	16,500	22,600	11,800	513	841	1,077
D			087	33,300	42,000	31,800			
630027	Millet	062	078	10,000	11,790	20,000	980	2,136	2,460
C			092	6,070	13,570	5,710	576	1,164	1,932
			117	7,860	9,290	9,640	376	644	524
			129	287,500	77,860	30,360	216	316	428
			145	4,645	18,930	20,000	76	82	140

*Farmers listed by their District, village, dwelling unit numbers.
Numbers beginning with 61, 62, and 63 denote the villages of Matobo, Mathangwane and Marapong, respectively.

**dates given in numbered days. for September 1 = 1.
C = Cattle draft; D = Donkey draft; M = Missing data.

***Treatments: 1 = Traditional, 2 = Early plowing, without P fertilizer,
3 = Early plowing plus 20 kg P ha^{-1}.

Table 2: TREATMENT MEANS FOR GRAIN YIELD (KG HA^{-1}) BY VILLAGE AND OVER ALL LOCATIONS, FOR THE DRAFT MANAGEMENT TRIAL, FRANCISTOWN, 1984-85.

Data Set	Observations	1	2	3	LSD (5%)	CVD
		-------Means (kg ha^{-1})-------				
Mathangwane	8	65	119	137	-	67
Matobo	6	452 b	845 a	797 a	276	31
Marapong	6	456 b	864 ab	1094 a	428	41
Overall	20	298 b	560 a	622 a	157	50

Treatments 1 = Traditional, 2 = Early plowing, without fertilizer 3 = Early plowing plus 20 Kg P ha^{-1}.

*Means followed by the same letter are not different at the 5% level.

CONDUCTING VILLAGE-LEVEL FEEDING TRIALS IN THE GAMBIA

S. L. Russo, N. A. Patrick and S. Deffendol

INTRODUCTION

The Gambian Mixed Farming and Resource Management Project is a collaborative effort between the Government of The Gambia, the Consortium for International Development (CID), and USAID with Colorado State University assuming the lead role. The project goal is "The intensified integration of crop and livestock production within existing Gambian farming systems" (Project Paper, 1979). The extended dry season from mid-October to mid-June places extreme ecological pressures on range resources with the result that livestock, especially cattle, experience significant weight losses and deaths every year. Reproductive capacity is similarly affected.

As more and more land is placed under cultivation, the competition between food production for humans vs. feed for livestock increases. In the Gambia, an important source of dry season grazing, swamplands, are being converted to rice production. Livestock thus spend more time on the rangelands which are consequently being overgrazed.(1)

Major project emphasis has been in two areas. The first has been trying to assure an adequate supply of relatively good quality forages to maintain the existing livestock, reduce weight losses and mortality during the eight month dry season, and decrease the age of first partuition. To meet the forage needs of livestock, there needs to be close coordination between the use of native grasslands, fallow lands, and crop residues (Alers-Montalvo et al., 1983). Range ecologists and forage agronomists are working in this area.

The second area of effort has been to increase maize production. This will increase the availability of maize stover for livestock use, assist the government in its goal of cereal self-sufficiency, add another cash crop the farmers can use to diversify production, and add another food crop to decrease the relaiance on imported rice. Maize was selected due to its relative productive capacity, high quality of stover residues, and the suitability of the soils and climate.

The maize component has been extremely successful in terms of farmer interest and acceptance. Research had been conducted for several years at the experiment stations and the project was able to go almost immediately to the field with maize demonstrations, both in cropping and food preparation. In 1983, 2500 ha of maize was planted, in 1984, over 12,000 ha were planted. Maize agronomists, a food scientist, and a home economist are responsible for this component.

The socioeconomic component (rural sociologist, agricultural economists, marketing specialists) concentrated on baseline and farm management studies for the first three years of the project. They are now working more closely with biological scientists in an attempt to pull all of the activities into an integrated effort at the village level and the evaluation of interventions.

Although the project was designed using the farming systems research and extension (FSR/E) methodology, most of its programs lend themselves to that approach. A few of the expatriate staff are FSR/E proponents, having

participated in FSR/E projects in other countries and all of the staff, both expatriates and Gambians, have had FSR/E training, either in the U.S., or via workshops presented in-country by the FSSP.

This paper will discuss village level trials with cattle, using stored grain stovers, and deferred grazing areas, in the eastern part of the country (Upper River and McCarthy Island Divisions).

SETTING

The Gambia is the smallest country in Africa, surrounded on three sides by Senegal on the west coast of the continent between 13 and 14 N latitude. The Gambia consists of land on either side of the River Gambia, never more than 30 km wide, and running east from the coast about 300 km. Total area of the country is 11,295 km2 with a total land area of just over one million ha. The country is riverine, with swamplands, croplands, and upland forest. The highest elevation is 50 m. The level of the river is affected by the tides throughout the length of the country.

The rainy season usually begins in June and lasts until October. Historically, 1000 to 1200 mm of precipitation fell during these months, but in the last few years, the drought in sub-Saharan Africa has reduced annual rainfall to 600 to 800 mm per annum. Little rain occurs the rest of the year. Temperatures range from 20 to 40 C, the lowest occuring at night between November and February. Aside from the alluvial soils near the river, the greater part of the land surface in The Gambia is formed from the Continental Terminal. These soils can be classified as ferruginous tropical soils, sand or loamy sand, with an increase in clay with depth, pH 5.8 to 6.4, low chemical fertility, brownish in color to the surface horizon (Dunsmore et al., 1976). In some area with increasing content of clay and iron oxide, the color becomes more red.

The 1983 census indicated a total population of 696,000 with an annual increase of 3.49%. Urban areas constitute about one-third of the population and are growing at about 6.5% per year. Rural residents live in villages composed of several to many "compounds" with most compounds containing between 6 to 20 persons. A compound consists of a man (the compound head), his wives and children, his brothers and sons and their wives and children, and various other members of the extended family. Seasonal workers, mostly from nearby countries, arrive during the rainy season to assist with the crop production in exchange for a plot of land on which they grow a cash crop. These individuals are called "Strange Farmers". While Wollofs are the dominant ethnic group in the area of the capital, the Mandinka are the largest group in the country, followed by Fulla (Peul), Wollof, Serehule, Jolla, and Serere. Villages are usually only one ethnic group.

Although private land ownership is now allowed in the urban areas, all land in rural areas is owned by the government. Administration of land is handled by the Ministry of Local Government on the national level, the Divisional Commissioner and District Chief, and the Alkalo (village head) at the local level. Compounds can obtain usufruct rights to cropland by clearing unused land. Most of this clearing took place in past generations, and in some villages, little or no land suitable for crops and uncleared, is available. Borrowing of cropland from other compounds is a popular way to increase crop area. Range/bush land for grazing is unowned, and generally uncontrolled.

Millet is the major produced foodgrain followed by maize, sorghum, and rice. Rice is a preferred food and large quantities are imported. The major cash crop is groundnuts, followed by cotton. Since 90% of foreign exchange is generated by the international sale of groundnuts and cotton, these crops receive priority attention by the government.

Livestock are very important both socially and economically. Large herds provide the owner with social status and the accompanying aspects of leadership. Livestock are also held for purposes of financial security and as a source of cash in times of an emergency. Athough the cattle herd in the Gambia totals over 300,000 head, with sheep and goats totalling somewhat more than this number, livestock are usually sold only when the owner must have cash. Offtake from cattle herds is estimated at 8 to 10% annually, much in the form of slaughter for religious and social events.

Credit is available through cooperatives and banks but farmers are accustomed to free credit via development projects or loans forgiven by the government and have a very poor repayment history. This year, subsidies on fertilizer were greatly reduced under IMF pressure, FAO ceased its credit program, and the Agricultural Development Bank closed. Farmers have consequently purchased very little fertilizer. Credit has been used in the past to purchase farm equipment and draft animals through a British aid project that no longer exists.

Cropping takes place from June through November although in some areas with access to irrigation, tow rice crops are grown per year. Cattle are tended by herder (usually Fulla) and taken away from the village, often into Senegal, during the cropping season. Sheep and goats are staked and tethered at this tme to keep them out of the crop fields. After the last harvests (groundnuts in November), cattle return to the vllages, and all livestock are left free to graze the stubbles and fields around the village. Increasing cultivation has encroached on the lands normally used for dry season grazing around the village as has increased forest clearing. Livestock begin to undergo severe nutritional stress by the middle of the dry season, and can lose up to 30% of their body weight before the rains provide sufficient feed in July. Last Year (1984), rainfall was significantly below normal and this year (1985), the rains were about a month late in most of the country and many cattle died of starvation.

The problem that the project was trying to solve was this loss of weight (and sometimes death) of cattle during the dry season. The interventions are the protection of range areas from uncontrolled grazing and the harvest and feeding of crop residues; the hypothesis being that making these feed resources available to cattle would prevent serious weight loss over the dry season. As a secondary benefit, the physiological maturity of animals would be hastened allowing the first calf to be born in the third year of the heifer's life rather than the typical fourth year (see following performance parameters for N'Dama cattle). It was recognized that not all cattle could participate in the limited feeding program and owners were asked to pick the group that would benefit the most. Owners chose young heifers (no calf yet) as the most likely to benefit from supplemental feeding.

Average age at first calving	34-40 months
Calving interval	29 months
Calving percent	41%
Calf mortality	30-45%
1-2 year mortality	3%

Offtake from herd 8-10%

The MFP team decided to work through Livestock Owners Associations (LOAs) because they were a recognized group already in existence, making contacts easier to manage. The LOAs were formed by the Department of Animal Health and Production in 1976; there are 42 in the country with at least one in each of the 36 districts. Most were inactive by 1984 except for those involved with the MFP, or with the International Typanosomiasis Centre (ITC) program.

RESEARCH DESIGN

Crop residues have not been used to any great extent by farmers in the past except for groundnut hay, fed to draft animals and sheep destined for religious slaughter. Groundnut hay is excellent feed, whose value is generally not recognized by most farmers. The hay is often sold to Senegalese traders by farmers who later watch their cattle die from lack of feed. Feeding trials conducted at the research station for several years had shown that maize stover, sorghum stover, rice straw, Andropogon gayanus hay (gamba grass), and groundnut hay all can at least maintain livestock weight over the dry season.

The feeding trials took place in four village groups in the eastern part of the country where the cattle population was most concentrated. This full trial consisted of two parts: 1) the harvesting, storage, and feeding of crop residues, and 2) fencing 10 to 15 ha of rangeland so as to control time and intensity of grazing. Farmer input was to include the following: 1) selection of the site for the fenced deferred grazing area, 2) provision of labor for building the fence using materials provided by the project, 3) harvesting and storage of crop residues, 4) selection of animals to be utilized in the trial and control groups, and 5) provision of labor for herding, watering, and feeding the animals. Thus, the trials were researcher-managed with significant farmer input causing variations in the design in each village. A simpler supplemental trial was carried out in seven individual villages using stored crop residues to augment their native range diets in May-June.

In 1984, the first feeding trial was held in the village of Boiram. Forty 2 to 2 1/2 year old heifers were loaned to the trial by the villagers. In an effort to assure adequate quantities of feed, crop residues were hauled to the feeding area by the project. Twenty animals remained in the fenced area while twenty stayed with the herd. Animals were weighed and girth measurements taken every two weeks. In January and February, they were fed maize stover, in March, sorghum stover, in April, they went into the range plot for two months and in June, they returned to the feeding area to eat groundnut hay. At the end of June, they rejoined their respective herd.

In 1985, the full trial was expanded to four villages: Boiram, Piniai, Sukuta, and Makamasareh. An additional 14 other villages attempted some aspect of a supplemental feeding program. These were: Garowal, Wellingara Kantora, Medina, Gunjun Taborkoto, Kolikunda, Sutukoba, Wellingara Wuli, Gunjur Jeka, Sinchu Koli, Kunsun, Sudowol, Baraji Kunda.

The full trial was to have two similar groups of heifers of equal numbers. One group would participate in the stover feeding and/or deferred grazing trial. The other would run with the herd under traditional management as a control group. All cattle would be ear tagged, dewormed, and vaccinated for blackwater. Weights and heart girth measurements were to be taken every 28 days for all

animals.

The village level supplemental feeding trial augmented the open range diets of heifers during the hungry months of May to June. Varied amounts of maize and millet stover and rice straw were collected and stored on platforms in 900 m2 fenced areas. The number of heifers fed per village unit depended on quantity of residues stored. Animals were fed roughly 1% of body weight in residue.

In this paper, we will report on problems encountered in carrying out the researach and attempt to show why one must maintain a sense of humor while attempting research in the developing world. A brief section on conclusions will follow.

PROBLEMS AND RESULTS: 1985

Village with Full Trial Implemented

Boiram. The stover feeding and deferred grazing areas are both within one kilometer of the village of Boiram. With the LOAs covering several villages, it was inevitable that some cattle owners who wished to participate in the trial would live in villages some distance from the trial site. This was not foreseen to be a problem prior to the first year trial in 1984. However, as the trial progressed, the participation in feeding and watering diminished to the point where Boiram residents were doing all the work. This was particularly worrisome to the Boiram women, whose traditional responsibility is to draw water from the wells for watering the livestock. In 1985, the farmers of Boiram decided to charge 15 dalasis (about $4) per head to all non-Boiram cattle placed in the trial to cover this extra work. This resulted in most non-Boiram cattle being withdrawn from the trial, and numbers dropped from 40 in 1984 to 29 in 1985.

As mentioned previously, during the first year of the trial, the project contributed a lot of labor in terms of tractors and trucks to haul crop residues because we wanted to test the hypothesis that feeding crop residues was beneficial. The second year, the farmers were to take over this responsibility. They argued that we should do it; we didn't, as a result not enough residues were hauled, and they were of low quality by the time they were picked up from the fields and delivered to the feeding site. All stored groundnut hay mysteriously disappeared in mid-May.

A further complication was that farmers had carts but claimed they needed some form of repair before they could be used. A most common requirement was tires. After some deliberation, the project purchased a number of used tires, delivered them to Boiram, and sold them at cost (29 dalasis each) to the farmers.

The maize component of the project had had a fertilizer and seed credit package in Boiram in 1984 to promote maize production. Despite documented good yields, the farmers claimed they could not afford to repay the loans, so in 1985, the project provided the village fertilizer on credit only to those farmers who had paid their loans. The farmers then tried to use the feeding program as a lever, saying that they would not participate if they didn't get credit. When we refused this gambit, they continued to work on the feeding trial.

To top it off, the village herd left the area in March (rather than June

as is normal) to seek grazing, so most of the control group couldn't be weighed.

Pinai. Eleven villages participated in the Piniai trial. The range and feeding area was situated between the villages at an old village site. An old well was rebuilt at project expense. Specific days were set aside each week for hauling crop residues by donkey cart and significant quantities of good quality maize stover was harvested and stored. On March 10, 1985, four days after the trial began, honey-seekers trying to smoke out some bees, set a bush fire that consumed about 1000 ha of range and fallow cropland including the feeding trial area. All the stored crop residues were destroyed and the cattle escaped being killed when the farmers cut the fence to turn them loose. The trial was abandoned for 1985.

Sukuta. Farmers in this area worked hard to harvest and store, on wooden platforms, sufficient quantities of good quality maize stover. The LOA had contracted with a herder to water and feed the cattle during the trial.

An unprecedented series of heavy rains in December caused the stacked stover to dry rot losing well over 75%. The project hauled gamba grass hay from one of the research stations to replace the spoiled maize stover. Several trips were required, involving about a one hour drive each way plus two ferry crossings, one of which was a hand pull cable ferry.

Another serious problem was that unbeknownst to the team, the chosen range area to be fenced was a bush pig habitat. The pigs made many cannonball sized holes in the fence going to and from their home to water. The villagers managed to shoot several pigs while they were foraging inside the fenced area.

Makamasareh. The fourth village that has a fenced range area is a very isolated village so far in the northeastern part of the country that it appears, on some maps, as being in Senegal. The drought has hit this area hard and crop yields were very low in 1984. In spite of wells being very deep, they are dry most of the day during the dry season. The Alkalo is conservative and reluctant to do anything; villagers follow his lead. During early months of the dry season, he threatened to take all cattle out of the village to an area near the river if the project, or some other agency, didn't provide an improved water source. Only 200 kg of mostly barren maize stover was collected and stored. Four other villages participated in building the fence around the range area but were too far (6 to 12 km) to participate in the feeding trial. Finally, a U.N. agency did provide machines and hire labor to deepen one of the existing wells. No control group was established.

Supplemental Feeding Trials

At Garowal, the area fenced was right next to the river accessway. Village women hung clothes to dry on the fence, causing the barbed wire to sag. Since livestock passed that way daily to drink, the stored crop residues quickly disappeared and consequently there was no feeding trial.

Most of the other villages did not really believe that the crop residue feeding would work and only a few farmers participated, limiting quantities of residues collected. Usually maize stover, millet stover, and/or rice straw was collected. The heifers would be put inside for a couple of hours, staked, and fed by their owners individually, then released to graze on open range. In some villages, owners would bring their animals twice a day. Villagers became believers in some cases when the rains were delayed this year and there was 4 to 6 weeks of feed available to animals who otherwise would have had slim pickings. Supplemented heifers were watered with range fed animals, from hand drawn wells.

The five villages who helped build the fence in Makamasareh were Wellingara Wuli, Madina, Gunjur, Faborkato, and Kolikunda. They all belong to the same LOA, but did not participate in the feeding trial at Makamasareh because they said daily watering would be impossible, it was too far to come every day. Instead they constructed 900 m2 fenced areas, brought crop residues there and supplemental fed their heifers in May and June.

In all 18 villages, crop residues were often provided by non-LOA members and even non-livestock owners. The trials were seen as a community effort. Non-members and non-participants (in terms of actually having an animal in a trial) felt that to have an activity in their village that was successful or at least brought outsiders in (Ministry personnel, technical experts, etc.) might lead to their village being chosen for another activity. This other activity would not necessarily have to be livestock-oriented. What villagers wanted was visibility and to be put "on record" as being cooperative.

Results for 1985

Boiram. After 22 days on the maize stover, 12 animals averaged daily weight changes of -.13 kg. Last year, after feeding maize stover for 28 days, average animal daily weight change was -.06 kg. After the maize stover was finished, animals moved to the 2 ha fenced forage plot for 10 days and then onto the deferred range plot (10 ha) for 77 days, where 12 heifers averaged daily weight changes of -.02 kg. Average animal daily weight changes over the entire 112 days was -.06 kg. The control group was insufficient in number to give comparison between the 12 fed heifers.

Piniai. There were no results due to the bush fire.

Sukuta. Hay furnished 1200 kg useable dry matter to 26 heifers for 26 days at an average animal daily gain of .14 kg. The heifers were then placed in the 15 ha deferred range plot for 58 days with limited amounts of rice straw being supplemented the last 10 days. Average daily gain was .09 kg.

Average animal daily gain for the 87 day program was .11 kg. The control group of heifers was insufficient in number to give a good comparison between the 26 fed animals.

Makamasareh. The 28 heifers were started directly onto the deferred area on April 17 and continued through July 3 (78 days). No body weights were taken because of lack of an available platform scale in the area; however, girth measurements were made at the beginning and end.

CONCLUSIONS

In The Gambia, livestock can maintain body weight through later months of the dry season by using combinations of crop residues and/or protected deferred rangeland. Deferred rangelands are forage reserves protected and often reseeded to improve productivity. They are managed for optimum livestock grazing during a particular season of the year. Crop residues are abundant at harvest time, but improperly used at a time of year when other, natural plant growth is abundant. There are not enough residues to feed every animal during the critical dry season. The farmer, or group of farmers, must make the decision as to what livestock are to be fed. The farmers working with MFP have chosen to feed their future breeding stock, heifers, starting at one year of age.

Feeding combinations of crop residues depend largely on their availability, care in handling, and storing. Maize is early maturing, maturing while the rains are in process, and the stover requires bunching or bundling vertically for field storage during and just following the rains. It requires little additional farm labor to cut the stalks, bundle them, and stack vertically in groups. Dry cobs can be harvested from the vertical field stacks. If, however, the field stacked stover is moved to a centrl storage area, usually fenced, then additional labor is required as well as transport.

It is possible in some village areas that residue production may be limited, or entirely lacking. In the case of Makamasareh, this year the maize crop failed, and farmers did not have adequate crop residues for the planned combination residue and deferred rangeland feeding program. The alternative was to skip the residues and start directly onto the deferred rangeland but at a later date (17 April). The 28 heifers remained on the range area for 78 days, being removed on 3 July. Deferred rangeland, when adequate drinking water was furnished daily, maintained average individual animal daily weights through 56 to 77 days (Boiram 1984 and 1985; Sukuta 1985).

Recommended 3 Month Feeding Strategy for 1-3 Year Old Heifers:

April ..... feed 28 days....maize stover (2% body weight)
May/June... feed 49 days....deferred range plot
June ..... feed 14 days....groundnut hay (2% body weight)

It is important to keep animals in the feeding program, maintaining body weights, until outside range conditions provide adequate dietary requirements to maintain the animal. In normal years in Upper River and MacCarthy Island Divisions, early seasonal rains provide sufficient biomass by 30 June. Another precaution is not to overstock the deferred rangeland trying to make up for the lack of stored residues.

MFP recommends early feeding of maize stover to heifers. In the case of Boiram, (1984 and 1985) maize stover was fed the first 28 and 24 days, respectively, animals consistently produced slight body weight reductons, but good to excellent body condition. Maize stover should not be fed alone towards the later stages of a feeding program.

Seven villages collected and stored crop residues within a fenced exclosure that they built with MFP provided materials. (Three additional villages were presented with the proposal and three implemented some portion of infrastructure, none collected residues nor fed animals.) MFP's recommendaton of supplementing the daily range diet of participating heifers was followed, but feeding methodology differed from village to village. Heifers were tethered inside of the exclosure either once or twice a day and individual owners placed a quantity of residue before their animal(s). A prescribed quantity of residue was demonstrated to the farmer, about 2 kilos of residue was recommended for each animal, or about 1% of a 90 kilo animal, tmes 40% useability. Various bundles of maize stover and rice straw were weighed until an appropriate hand bundle was demonstrated. The recommended ration was more than met. Animals were in good condition following the feeding that lasted an average of 5.4 weeks for 139 heifers, and started the first week in May.

Stockmen were surprised with the palatibility of the maize stover and acceptability to the heifers, and the condition of the animals after eating it for a few weeks. Also, rice straw fed in the later stages of the dry season resulted in no body weight loss.

The team worked through the LOAs because they were an already identifiable clientele. The program might be moe successful if it were on a village by village basis rather than a multi-village LOA basis. People from other villages tended to see benefits accruing only to the village where the trial was held. Distances between villages, while not far for an occasional LOA meeting, became insurmountable for humans on a daily basis.

Norman (1985) states that the likelihood of institutionalizing is heavily dependent on credibility, trained and motivated nationals, and a program that uses minimal resources. The program achieved credibility in most of the villages when livestock owners could see the differences in both the condition of the cattle in the feeding program and the condition of the areas that had been deferred from grazing. It was estimated that the areas protected from grazing had 4-5 times as much biomass as the surrounding areas.

The backbone of the program has been the pasture assistants who are posted in the area and have between two to six villages to take care of. The project has provided motorcycles, spare parts, allowances, and training. The government provides their salaries. It is a fact of life in The Gambia, that if a Ministry employee is not attached to an external aid project, then the employee is essentially immobile. Fuel allotments to senior officers with trucks are 40 litres per month when there is fuel. How are the pasture assistants going to get encouragement to continue their work? The feeding program hinges on continued professional visits by the pasture assistants because it is not a routine in the villages yet. Farmers have seen the beginning of the concept but they need follow-up visits to sustain their efforts.

Allowances for the pasture assistants, fuel, motocycles, repairs are all recurrent costs. The fencing-steel and treated wooden posts, barbed wire, is not locally available. Clearly, some aspects of the program do not fill the requirement of "minimal resources". Yet, the government is working toward a means of handling recurrent costs at the insistence of IMF and the World Bank and fences can be built out of locally available materials or cattle could be herded throughout the year.

Problems at the village level mentioned earlier, (bush fires, bush pigs, inter- and intra-village rivalries) are best handled by patience and a sense of humor. We are promoting concepts that historically have not existed and may not be rational from the farmer's viewpoint. These concepts will not be accepted overnight, within one season, or possibly not even in our lifetime. Of course, when the donor agency (AID in this case) is constantly looking for five year project success stories, such a long term view is not acceptable.

The last, but not necessarily the least problem, has been philisophical, as it were. All of the MFP staff have had training and exposure to FSR/E concepts, yet the concept of the synergism of interdisciplinary work has not been accepted by all. In discussing implementation, Shaner et al. (1981) mentions that even teams sharing common goals may have difficulty communicating across paradigms and defining and agreeing upon objectives. One-on-one communication works well, but when more than two disciplines get together, communication tends to be reduced to a minimum. Continued efforts must be made to maintain dialogues. This has been frustrating because one tends to lose the patience and sense of humor one has when dealing with farmers as expectations of peers are somewhat higher. Nevertheless, the admonitions useful for working with farmers prove to be just as useful when working with team members.

FOOTNOTES

(1) Overgrazing is a term usually used by expatriates. In a traditional African grazing situation environment degradation is an unknown concept and grazing lands are owned by noone but used by everyone. This is a rational and optimum strategy for individual farmers.

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IMPROVED INTEGRATION OF LEGUMES INTO THE AGRO-PASTORAL SYSTEM OF THE NUBA MOUNTAINS, SUDAN

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THE PHYSICAL ENVIRONMENT

The research area occupies approximately 30,000 km^{-2} in the Nuba Mountains of South Kordofan between $10^{o}30'$ and 12° North Latitude, and $29^{o}10'$ and $30^{o}40'$ East Longitude (Figure 1). The region lies within the savanna zone of the Sudan-Sahelian belt and is classified as having a hot, semi-arid climate with a mean annual rainfall ranging from 600 mm in the north to over 800 mm in the south. Rainfall varies considerably in amount and distribution from year to year, but occurs in a single season from late May to mid October, leaving an extended dry season of six to seven months.

Topographically, the area is characterized by flat or gently undulating plains of cracking and non-cracking clays, interspersed with rocky hill ranges and their footslopes of sandy loams and clays. Elevation varies from about 500 m in the plains, to over 800 m on hilltops. The plains account for about 60% of the land surface with the hills and footslopes occupying the remaining 40%. The most extensive and important soils in the area are dark brown, deep cracking clays similar in structure, texture, and physical characteristics to the vertisols classified by Buol et al., (1980) and the USDA Soil Survey Staff (1975). In the Nuba Mountain region, cracking clays are derived from in situ weathering, or from locally translocated weathering products of base-rich Basement Complex rocks (HTS, 1980). They are typically over 200 cm deep, have high clay contents of about 60%, and are dominated by the expanding, lattice clay montmorillonite which causes expansion when wet and contraction when dry. In the dry state, a shallow friable mulch often forms at the surface, and cracks up to 150 cm develop vertically into the profile. At the start of the rains, infiltration into the profile through the cracks is rapid, but slows considerably once the cracks are sealed. Cracking clays exhibit extremes of consistency from very hard when dry to very plastic when wet. Consequently, the optimum moisture content for tillage, planting and crop growth lies within narrow limits.

Cracking clays in this area show a ph of 7.4 to 8.4 (Bunderson, unpublished data), and have high cation exchange capacities, with calcium and magnesium dominating the exchange complex (HTS, 1980). Low levels of nitrogen, phosphorus, and organic carbon have been reported for these soils (HTS, 1980, 1981; WSARP, 1983; Gingrich, 1984; GTZ, 1984). The response of sorghum to nitrogen and phosphorous fertilizer at 40 kg ha^{-1} alone and in combination provided further evidence of low soil fertility (Gingrich, 1984; Woldetatios, 1985).

Vegetation is heterogeneous, corresponding largely to changes in soils and relief, but is broadly classified as wooded savanna dominated by annual grass, with varying proportions of deciduous and evergreen trees and shrubs (Bunderson, 1981; Bunderson et al., 1984).

SOCIOECONOMICS

The rural human population of the research area in the Nuba Mountains exceeds 500,000 at a density substantially higher than any area of comparable size in Western Sudan. The region is a major crop producing area and supports a large population of resident and migratory livestock, including 350,000 cattle, 100,000 sheep, 300,000 goats (HTS, 1980), and an increasing number of camels currently estimated at 75,000. Agricultural activities are dominated by two groups, a predominantly sedentary group of tribes collectively known as the Nuba, and the Baggara transhumants of Arab origin. Attention in this paper is focused on the Nuba because these tribes represent the major cultivators of the region.

THE NUBA SEDENTARY SYSTEM

General Characteristics

The Nuba account for about 85% of the population, produce 90% of the crops, and own approximately 30% of the livestock (HTS, 1981). These people represent several tribes, but exhibit similarities in origins, traditions and agricultural activities. Villages are typically located on or in close proximity to hill ranges, although in recent decades there has been some downhill migration into the surrounding plains. Crop and livestock production generally span the entire topo-edaphic gradient from the rocky, sandy loam hillsides to the cracking clays in the plains.

In terms of land tenure, grazing land is communal and free, and there are no traditions concerning range management and pasture improvement, or of land enclosure for fodder production, fuel, or timber. However, many groups have maintained a limited degree of autonomy over rangeland by virtue of their greater numbers, sedentary nature, and control over water. By contrast, cultivators enjoy the benefits of a rudimentary system of land tenure, although the Government of Sudan holds residual rights to all unsurveyed and unregistered land. This system is primarily usufruct, where rights to cropland can be claimed by individuals, or inherited, as long as the crop-fallow system of cultivation is maintained. For regions with limited resources, use rights can be rented, purchased, borrowed, or obtained as gifts. In areas with plentiful land, usufructory rights can be acquired simply through land clearing.

Crop Production

Activities of the Nuba center primarily on crops with livestock assuming an important secondary role. Cultivation under traditional management involves no mechanization or animal draft, and is concentrated in the cracking clay plains, with emphasis on sorghum and sesame as the principal field crops (HTS, 1981; WSARP, 1983). The distribution and production of major crops raised by traditional households is shown in Table 1. Cultivation in the plains involves a bush-fallow cycle where land is cleared of native vegetation, cropped for 6-12 years, and abandoned for a similar period when soil fertility or infestation by *Striga* no longer support acceptable yields. Systematic crop rotations are nonexistent. Some partial intercropping of sorghum with sesame and/or cowpeas is practiced, but the latter are planted sporadically and at low densities. Under traditional practices, sorghum and sesame are widely spaced, usually

1.0 to 1.6 m between and within rows (Woldetatios, unpublished data). This appears an inefficient use of land, as well as providing space for increased weed competition. However, it may function to reduce the seasonal uptake of nutrients, thereby allowing continuous cropping for longer periods.

Sesame is frequently used for land coming out of fallow (HTS, 1981). It is also planted in areas heavily infested with Striga, or where soil fertility has been depleted by excessive sorghum cultivation (Woldetatios, 1985). According to local farmers, sesame promotes yields of subsequent sorghum crops following fallow, and also permits continued cultivation on land no longer able to support cereal production. Similar observations have been reported for crop rotation experiments by GTZ (1984) and the Mechanized Farming Corporation (M. A. Mahmoud, Director of MFC, pers. communications). Although there is no scientific documentation on the mechanisms involved, sesame may have the ability to extract nutrients at deeper soil depths, leading to improved nutrient availability higher in the soil profile.

Nuba farmers also cultivate housegardens or "jubrakas" and "near farms" which form an integral part of their production activities (Table 1). These sites are located on sandy clays and loams adjacent to the household, and function for added food security during the "hungry" period prior to the harvest of the far fields in December. Crop management and inputs are more intensive than the cracking clays because of less productive soils and longer periods of continuous cropping. Proximity to the household also facilitates greater labor inputs. Major activities include extensive thorn fencing from branches of the coppicing tree Ziziphus spina-christi to protect crops from livestock, and crude terracing by clearing the sites of rocks which are used to form low walls to contain water from runoff and prevent soil and manure loss. In the jubrakas and near farms, crop and livestock activities are reasonably well integrated. Following the harvest, livestock are grazed on crop residues during the day, and in the process deposit dung. This practice operates on a communal basis, and is encouraged even among households having little or no livestock. Manure is also gathered and stored from animals sheltered at night in separate huts or pens within the household compound. Stored manure is applied to plots by hand during land preparation.

Livestock Production

Livestock production among most Nuba tribes is based on a sedentary system of management dominated by cattle and goats. Sheep and swine are also raised to varying degrees according to individual preferences and the influence of Islam. There are recent trends for nomadization among some of the larger livestock holders due to an increasing ability to accumulate livestock. In earlier times, livestock circulated among people, but are now also produced for market. The accumulation of livestock was formerly inhibited by their extensive use in rituals of marriage and death, rites of initiation, compensation for homicide, and other forms of communal consumption. The threat of attack by raiders, coupled with restricted access to water and pasture, particularly in the plains, further limited holding size. Under current conditions, herds are increasing in size among both sedentary and transhumant Nuba due to greater security from outside threats, changing customs, and reduced restrictions on access to water and grazing.

Sedentary livestock management is characterized by relatively unrestricted grazing, frequently involving a seasonal catenary sequence of movement between hilltops, footslopes, and the plains (Bunderson, 1981; Bunderson et al., 1984). During the growing season, care is devoted in herding animals away from cultivated land, and in minimizing insect problems on livestock. Cattle are usually moved into the hills where bush enclosed camps are contructed for housing both animals and herders. Individual camps are typically operated by a collective group of related families managed entirely by boys and young men. Smoke fires involving manure and green vegetation are used to drive insects away during peak periods of pest activities, at mid-day for biting flies, and at night for mosquitos and other nocturnal insects. Milk is a major source of food for herders at this time, although grain is also used and is carried to the camps on a regular basis. In contrast to cattle, small ruminants are maintained around the household, grazing on nearby hillsides and footslopes during the day, and returning to the household at night along elaborately fenced pathways to prevent crop damage. Swine are generally kept in huts or pens during the jubraka growing season because of herding difficulties and consequent risks to crops. These animals are hand fed a variety of food ranging from native vegetation to household waste and low quality grain.

At the end of the rains, cattle are brought down from the hills, and crop residues in the jubraka and near farms are intensively grazed by all classes of livestock immediately after harvest. Specific residue components are selected by different species of animals due to differential feeding habits. For example, goats select green sesame leaves, shoot regrowth from sorghum, melon seeds, shattered cowpea leaves on the ground, and leaves from Ziziphus bushes which are common in these plots, while cattle grazing is limited primarily to dried sorghum stalks and leaves (Bunderson, in prep.). Groundnut tops are usually the only residue commonly harvested and stored. These are either fed or sold for supplemental feed late in the dry season.

With the depletion of crop residues from the jubrakas and near farms, livestock are moved to footslope grazing until the harvest of the far fields in the cracking clays in January. As with the other sites, cultivated fields become public domain once harvested, but their use on the cracking clays is more communal, involving transhumant and other village herds in addition to resident stock. Crop residues here consist mainly of sorghum stalks with some sesame, and are exhausted within one or two months, mostly by cattle. Cowpeas provide little fodder because of their low density and earlier harvest. The latter results in considerable leaf loss through shattering, wind, and soil mixing before animals are permitted into the fields.

During the late dry season from March to June, the majority of livestock are grazed on the native vegetation of the clay plains where they are frequently forced to travel 20 to 30 km day^{-1} for food and water (Bunderson et al., 1984). As the dry season advances, forage is depleted in expanding arcs from water, causing increased energy expenditures, along with reduced food intake due to declining forage quality and limited feeding time (Bunderson and Cook, 1985; Fadlalla et al., 1985).

Other Activities

Off-farm activities include extensive fencing of gardens and near farms, household repairs, and the production and sale of charcoal, wood, timber, and thatching for domestic and urban consumption. A limited number of producers with access to irrigated land grow vegetable gardens, principally for cash purposes. In some areas, there is significant out-migration of adult males seeking employment in urban towns, and of teenage boys serving as herders for Arab transhumants. Labor migration may be seasonal or of longer duration, with proceeds frequently used to build farm equity.

Production and Marketing Objectives

In terms of priorities, Nuba farmers are concerned first with meeting their subsistence household needs for food on a year round basis, a requirement largely dependent on cultivated crops. Surplus food and cash crops play an important role in achieving this objective, but these efforts are secondary to subsistence food production. In general, risk avoidance overrides opportunities for maximizing yield or profit.

Sorghum and sesame are the two major crops grown, accounting for 90% of the cropped area in recent years (HTS, 1980). Both crops are basic elements of the diet, but are also marketed. Cotton, once common in the area, has virtually disappeared from traditional agriculture due to low returns relative to other crops, a direct result of government controlled prices. Groundnuts and cowpeas are grown as minor subsistence/cash crops.

Livestock and livestock products provide important sources of protein in a starch dominated diet. Unlike their transhumant counterparts, milk is rarely sold but is consumed in the household. Animals, and other off-farm activities, also function as a stabilizing influence by supplementing household income, diversifying risk, and providing investment opportunities to allow improvements or expansion in agricultural production. Livestock are particularly important for household survival during years of crop failures.

Markets and Credit

The prevailing market system in the region involves both local and town markets. The latter provides more favorable prices for producers, but accessibility often limits any benefit gained. Prices for most crops vary considerably during the year depending largely on supply. Although farmers are price conscious, many are unable to defer sales to take advantage of higher prices later in the year. Those able to delay sales and cover transport costs to town markets are often those with income from livestock sales or labor migration. Most farmers sell a portion of the crops immediately after harvest to meet pressing cash needs. Formal lines of credit are generally absent, but farmers may undertake debts with shopkeepers in the form of "sheil" credit which is an advance of cash or goods to be repaid at an agreed value after harvest. More commonly, farmers engage in a barter system with shopkeepers where crops are exchanged for other produce or goods in lieu of cash. Informal lending among relatives and friends is also common.

For livestock, most farmers trek their animals to a near by town market where they are sold for cash. Milk sales among the Nuba are rare, although animal hides are commonly bartered or sold. Cattle sales generally involve mature males or animals that are old, lame, diseased, or unproductive. Mature females are rarely sold in the interest of maintaining or increasing herd size. Similar patterns prevail for small ruminants, although females are also marketed since herd size among sheep and goats can be more readily increased. Livestock prices vary considerably with market supply, illustrated by the enormous decline in prices for all stock following the flood of animals in the market during the recent drought in Sudan.

Inputs and services for traditional rainfed agriculture are extremely limited. Improved seeds, fertilizer, seed dressings, exposure to new technology, and formal credit systems are generally unavailable. Major obstacles include a poorly developed infrastructure, policy regulations on imported goods, low household capital, and a lack of knowledge of how to effectively improve traditional agriculture.

IMPROVED INTEGRATION OF LEGUME CROPS

Rationale

1. Crop Production

Legumes are currently grown on a limited scale by the Nuba, and consist primarily of groundnuts and cowpeas (Table 1). Grain yields from these crops are low, particularly in dry years, when yields may approach zero (Woldetatios, 1985). Groundnuts are primarily a cash crop but are also consumed. Cowpeas represent a valued component in the diets of Nuba households. In a survey of local farmers, 100% produced cowpeas for consumption and 56% sold surpluses for income (Gillard-Byers, 1985). Only sorghum and sesame were sold by a higher percentage of farmers and had higher food preference ratings. Observations over a four-year period show that cowpeas have a high market demand, selling for one-two times the price of sorghum depending on season. Cowpeas are also commonly available in markets, illustrating their value as a subsistence cash crop.

A major constraint to crop production is low soil fertility, particularly nitrogen and phosphorus. This is exacerbated by extended periods of cereal cropping, and the resulting dependence on a bush-fallow cycle of cultivation in the cracking clays where most crops are grown. Under current practices, the proportion of land in fallow is substantial, and often exceeds the area under crops. This relationship is illustrated by the following expression:

$$\text{Area In Fallow} = \frac{\text{Area Currently Under Crops}}{\text{Years Consecutively Cropped}} \times \frac{\text{Years In Fallow}}{\text{Prior to Fallow}}$$

For a system involving 8 years of continuous cultivation, followed by 12 years of fallow to regain fertility, the percentage of land in fallow relative to that under crops is 60:40. The dependence on a large area of land functions as an important crop constraint, which is becoming increasingly significant for the following reasons:

(1) households must maintain and have available relatively large areas of land to support continued cultivation; with increasing human

population growth and associated land use pressures, availability of land will steadily decrease;

(2) costs of clearing fallow land are high, and frequently lead to delayed planting with adverse consequences on crop yields;

(3) forced reductions in the fallow period, without soil fertility inputs, will result in declining crop yields; this situation will likely deteriorate in the near future due to rising demands on the decreasing availability of land.

Increased production of legumes as an integral component of the Nuba system offers potential for improving the productivity of agriculture on both a household and region wide basis. For example, in the Sahelo-Sudanian zone of West Africa, medium cycle length legumes such as cowpeas have yielded valuable quantities of grain during recent drought years, while sorghum, millet, and groundnuts have often failed to produce food (Hall, 1985). Newly developed early varieties of cowpeas have yielded up to 1000 kg ha^{-1} of grain during a 60 day growing season with less than 300 mm of effective rainfall (Hall, 1985). Food legumes provide good quality grain that combines well with cereals due to the high protein content of legume grain (e.g., 20 to 25%) and the complementary profile of essential amino acids. Many legumes also have substantial rates of nitrogen fixation to partially maintain soil fertility. Even with total removal of grain and forage, useful quantities of nitrogen can accumulate in the root zone (e.g., 20 kg N ha^{-1}). In addition, legumes such as cowpeas can be productive in soils low in phosphorous due to symbiotic associations with mycorrhizae (Hall, 1985).

In terms of crops, the objective for expanded legume cultivation is to stabilize or improve the agronomic resource base, and to enhance the household diet during periods of food shortage. The strategy involved is to introduce a simple system for intercropping sorghum and sesame with legumes that are well-adapted, freely nodulating, and high yielding in grain and forage. Anticipated results are:

(1) stabilized yields of cereal and oil seed crops in a system with a longer period of continuous cultivation;

(2) reduced incidence of Striga, insects, disease, and weed competition;

(3) increased assurance against total crop failure from drought or pest damage;

(4) shortened fallow periods with reductions in the relative proportion of land in fallow vs that under cultivation;

(5) reduced time and labor costs in clearing new or long abandoned land
(6) improved diets of households from September to January during the "hungry" period.

2. Livestock Production

For livestock, major constraints are related to poor nutrition during the dry season caused by inadequate supplies of forage and water. Studies of cattle and sheep under traditional management in the Nuba Mountains showed

body weight losses of 20 to 25% during the dry season, most of which occured during the last 3 months of the season, i.e., March to June (Bunderson et al., 1984; Cook and Fadlalla, 1985; Bunderson and Cook, 1985). Both cattle and sheep were in a negative nitrogen and energy balance during the dry season compared with a positive one during the rainy season (Fadlalla et al., 1985; Cook and Fadlalla, 1985). Mature bullocks (225 to 250 kg) in these studies had crude protein intakes of 160 g day^{-1} and 515 g day^{-1} during the dry and wet seasons respectively, while the energy density of the grazing diets ranged from 1.38 to 1.71 Mcal of metabolizable energy kg^{-1} dry matter for the same periods. For pregnant and lactating cattle in particular, this indicates substantial deficiencies in protein and energy during the dry season. Similar patterns were observed in sheep, but with energy being the most limiting factor caused by low forage availability (Fadlalla et al., 1985; Cook and Fadlalla, 1985). Pregnant and lactating ewes showed dry season energy deficiencies of 18.5 and 56% respectively, and a digestible protein deficiency of 16% for lactating females. These animals were also clinically deficient in plasma phosphorous with levels of 3.19 mg p 100^{-1} ml of plasma. For lactating Nuba goats, preliminary data showed a decline in fecal nitrogen levels from a mean of 16% at the end of the rains to 11% in the late dry season (Bunderson, in prep.). Obvious limitations in forage quality during the dry season are apparent from Table 2 which shows crude protein contents for common crop residues and native plants in the area compared with cultivated legumes.

Although the Nuba value cowpea and groundnut residues for livestock feed, opportunities for supplementation during the critical months of the late dry season are limited. Groundnut tops may yield 1 to 1.5 tons dry matter ha^{-1}, but the area cultivated is usually less than 1/5 ha per household. This is sufficient to supplement one-two mature cows (250 kg) for about 60 days during the dry season. Fodder yields from cowpeas under intercropping practices are low, and in the cracking clays, labor for harvesting and transport is limited by the distance from the household (i.e., commonly 5 km or more away). Similar problems are encountered with residues from other crops, making their conservation impractical, particularly low quality sorghum residues. With the exception of groundnut tops, crop residues are consumed by village and/or migratory herds well before the most critical period of the dry season, namely March to June. Nutritional stress at this time is particularly acute for pregnant and lactating females, with consequent impacts on young stock. Effects of poor nutrition are compounded by reduced resistence to disease and parasitic problems, leading to increased mortality among most animals.

In natural rangeland, forage limitations are partly related to widespread burning which frequently induces undesirable changes in the vegetation, as well as removing 30% of the net annual primary productivity (Bunderson, 1985). Sound grazing practices for improving the quality and availability of range resources are also absent. In addition, the large proportion of fallow land has implications on the forage value of these pastures. This is due to the disruptive effect of periodic cultivation on the establishment and growth of desirable forage plants (i.e., fallow vegetation is maintained at low seral stages of succession).

Under the prevailing system of communal grazing, livestock production is ultimately limited by the inability of producers to control the resource base for improved grazing management and pasture production. Until land-

use policy and planning issues are effectively addressed in collaboration with producer groups, alternative approaches are needed for improved productivity.

In terms of improved livestock production, legume research was focused on:

(1) supplying harvestable yields of high quality fodder from well-adapted food legumes to meet protein and energy maintenance levels of breeding stock during the late dry season, and

(2) improving the grazing value and utilization of fallow land.

Increased legume cultivation in the cracking clays shows promise for enhanced farm productivity and a better integration of crops and livestock. Payoffs are expected to be relatively short-term since the value of legumes for grain and forage is familiar to Nuba communities. The results could also have application over much of Western Sudan, including private and government operations.

Research conducted over the past two years included variety trials on food legumes, namely mung beans, cowpeas, and soybeans (Gingrich, 1984; Woldetatios, 1985), as well as screening tests and on-farm trials with forage legumes (Bunderson et al., 1984; Bunderson, 1985). Screening trials involved the following genera: Vigna, Clitoria, Phaseolus, Macroptilium, Centrosema, Cyamopsis, Dolichos, Lablab, Stylosanthes, Canavalia, Leucaena, Sesbania, Desmodium, Glycine, Alysicarpus, Cajanus, and Crotalaria. Emphasis was placed on the cracking clays since these are the dominant soils in the region and show the greatest potential for crop improvements.

Food Legumes

Several species and cultivars showed good performance and adaptibility to the local environment, despite drought conditions during 1983 and 1984. Legumes identified with high potential included:

(1) cowpeas (Vigna sinensis), with varieties CB-5, 8047, b58-57, 58-185, M-80, and M-66 yielding over 300 kg ha^{-1} of grain in 1983 and 1984

(2) mungbeans (Vigna radiata), with five varieties yielding over 577 kg ha^{-1} of grain in 1983, and over 597 kg ha^{-1} in 1984; these were (a) VC 1482 A/VC 1628A, (b) VC 1481 A/VC 1560A, (c) VC 2388 A/VC 1177, (d) VC 1481 A/VC 1628A(B), and (e) CES ID-21/EG MG-16.

All soybean varieties had poor nodulation and low yields due to pest damage and low rainfall, indicating poor adaptibility. The local cowpea varieties failed to produce grain because of their long maturing nature (> 100 days) and low rainfall, whereas the short maturing exogynous varieties (averaging 61 days) produced full pods of beans. The specified mung beans were also early varieties with an average of 60 days to maturity.

Forage Legumes

Several indigenous food legumes were included among the forage types. Legumes producing high yields of forage with excellent nodulation, and

resistence to drought, insects and disease included:

(1) mung beans, a variety obtained from the Agricultural Research Corporation (ARC) in Khartoum with a yield of 2.2 tons ha^{-1} of dry matter in 1984;

(2) two cowpea varieties, one from local farmers and one from the Range and Pasture Administration (RPA) in Khartoum yielding up to 1.4 tons ha^{-1} in 1984; in 1983 GTZ and RPA reported yields of over 2 tons (personal communications);

(3) guar (Cyamopsis tetragonobola) a variety from RPA yielding 1.8 tons ha^{-1}

(4) phillipesara (Phaseolus trilobus), a variety obtained from the ARC in Khartoum yielding over 1 ton ha^{-1} in 1984.

Ironically, the best forage producers namely mung beans, cowpeas, and guar also showed high potential for grain production. Although the local cowpeas yielded little or no grain because of low rainfall and their long maturity, the local mung beans and guar produced pods full of beans with yields of the former between 200-400 kg ha^{-1}. The resin from guar can also be used as a commercial cash crop. With improved plant spacing and normal rainfall, grain and forage yields should increase by 75 to 100%.

DISCUSSION

Based on these results, the important issue was how to make the expansion of legume crops attractive to farmers. In 1983 and 1984, farmer assessments of on-farm trials involving sole cowpea and forage legumes indicated that legume monocropping on the cracking clays was unlikely to be adopted due to conflicts with labor, land, and capital needed for other cropping activities (Gingrich, 1984; Bunderson, 1985). In contrast, cowpea intercropping trials under researcher-managed conditions in 1984 were received with enthusiasm and interest because the practice fit well into their existing system. There have since been high demands for the newly introduced cowpea varieties. Potential conflicts and labor reallocation for other activities remain to be tested in farmer-managed trials. To elucidate farmer perceptions, economic evaluations assessed the costs and benefits of legume monocropping vs. traditional and improved intercropping with sorghum. The latter entailed superimposing improved legume varieties on traditional sorghum crops. No reduction in sorghum yield was expected because of the excessive spacing used in local practices. The results in Tables 3 and 4 demonstrate the economic advantage of improved legume intercropping. They also indicate difficulties with introducing crop rotations involving sole legumes.

Current and Proposed Research

Information from economic analyses and from farmer surveys indicated that research should concentrate on legumes with potential for both grain and forage. Further, legume monocropping provides little attraction relative to intercropping under current farm conditions. For traditional practices to change, legumes must provide significant production benefits other than what is gained through improvements in soil fertility.

Forage crops offer little economic incentive because farmers are reluctant to devote land, labor, and capital for cultivating fodder when the activity competes directly with important food and cash crops. This conflicts somewhat with the research of ILCA on fodder banks, which suggests that confining livestock to specific areas serves to eliminate the labor costs of forage production (Chater, 1985). There still remain the costs of planting and weeding, and of controlled livestock confinement. Fodder banks also assume that some form of protection is offered the crop during growth, as well as for the period prior to supplementation. This would require physical control, such as fencing, or radical changes in the communal systems of land use which currently prevail over most of Africa's grazing land. The latter form of protection appears particularly unrealistic, at least in the short-term. If fencing is not possible, or harvesting is necessary to conserve forage quantity and quality prior to its feeding, then the costs of harvesting and storage must also be born by the farmer. Fodder banks raised by ILCA also required applications of phosphorous fertilizer, and involved an exotic forage legume with potential disease problems.

Costs of legume intercrops are significant but on a much reduced scale because no additional land is needed, and labor for land preparation and weeding is already allocated for the production of the main cereal crop. Intercrops could actually assist in reducing weed competition, thereby freeing up some labor. Remaining costs include planting, harvesting, transport, and storage. The latter costs are high for forage relative to grain. These are being addressed through the introduction of animal-drawn carts to alleviate labor bottlenecks associated with the harvest and transport of traditional food and cash crops in the cracking clays, as well as potential forage crops (Bunderson et al., 1984; Gillard-Byers et al, 1985). Implementation of on-farm trials using ox-drawn carts with over 60 producers in 1983/84 has created immense enthusiasm among Nuba farmers to adopt the technology. In these trials, producers elected to transport crop residues, grass thatching, and wood in addition to crops, indicating probable use for transporting legume forage. Improved storage structures are also being tested in order to handle larger volumes of fodder.

Current and future research in the Nuba Mountains is focusing on appropriate varieties of cowpeas, mung beans, and guar in both on-station and on-farm trials (Table 5). Emphasis is placed on short maturing, erect varieties for grain production, but spreading or leafy forms are also under evaluation because of the added benefit of forage. In parts of West Africa for example, a dual-purpose cowpea is grown where the value of the hay is often as great as that of the grain. Spreading forms also provide more complete ground cover which decreases weed competition and increases solar radiation and overall productivity, along with reduced surface runoff of water and soil erosion. Research on different but well adapted varieties allows producers to make their own selections to best meet their needs. Intercrops with sorghum are emphasized for the following reasons:

1. Traditional intercropping between sorghum and cowpeas has not been adequately evaluated from either a biological or economic perspective, and sesame-cowpea intercropping is rare or absent. Furthermore, continuous monocropping practices with cereal crops accelerate the depletion of soil fertility, and create favorable conditions for Striga and other pest infestation.

2. In order to determine sorghum/sesame-legume compatibility, future trials should involve early and long maturing varieties of these crops. Early planted crops of short maturing legumes and sesame will provide assured harvests of high quality food prior to the sorghum anthesis stage, thereby minimizing competition for water and nutrients during the critical stage of sorghum kernel synthesis. Relay crops of early varieties can also be sown into fields of early sorghum varieties at the time when the sorghum is heading. This would not affect the yield of sorghum and could produce a bonus crop of legume grain or forage.

3. Legume intercropping is being superimposed on both the traditional and improved row spacing of sorghum and sesame, such that yields of the main crop will not be reduced. Intercropping could show a significant increase in grain and protein production with distinct economic advantages over standard sorghum monocropping.

4. The benefit/cost ratio of improved legume intercropping for farmers is high and represents minimal change in traditional practices; adoption rates should therefore be high, as indicated by current on-farm trials.

5. Given the southward rate of desertification and the increasing demand for cultivable land, bush-fallow systems of crop production must be curtailed. Sound methods of intercropping with legumes should reduce the need and dependence on fallow land.

Legumes also show potential for use on land about to enter fallow after soil fertility has been exhausted by cereal production. In this regard, legumes could replace or enhance the current function of sesame.

Initial on-farm trials are concentrating on cowpeas since this is a recognized traditional crop, and difficulties commonly encountered with introducing new crops will be avoided. Although generally unfamiliar to local farming communities, mung beans and guar have demonstrated excellent agronomic performance under adverse environmental conditions. They also retained their leaves much longer after physiological maturity, indicating greater potential for hay. Mung beans in particular out-yielded cowpeas, producing almost double the production of both grain and forage. Mung beans and guar are being investigated for their potential market value and food acceptibility among Nuba households. The Nuba Mountain Corporation in conjunction with GTZ are currently evaluating mung beans as a rotational crop in their mechanized schemes. Preliminary assessments indicate favorable producer attitudes, which could rapidly establish an acceptable market for the crop. Assuming positive results from food and market studies, on-farm trials with guar and mung beans should follow successful improvements with cowpeas.

Well-executed improvements in legume intercropping could substantially reduce current limitations of crop production in the Nuba Mountains. Recent feeding trials with livestock also indicate that animal nutrition and productivity can be significantly improved through dry-season supplementation with legume forage (Bunderson and Cook, 1985; Hashim and Bunderson, 1985; Cook and Fadlalla, 1985).

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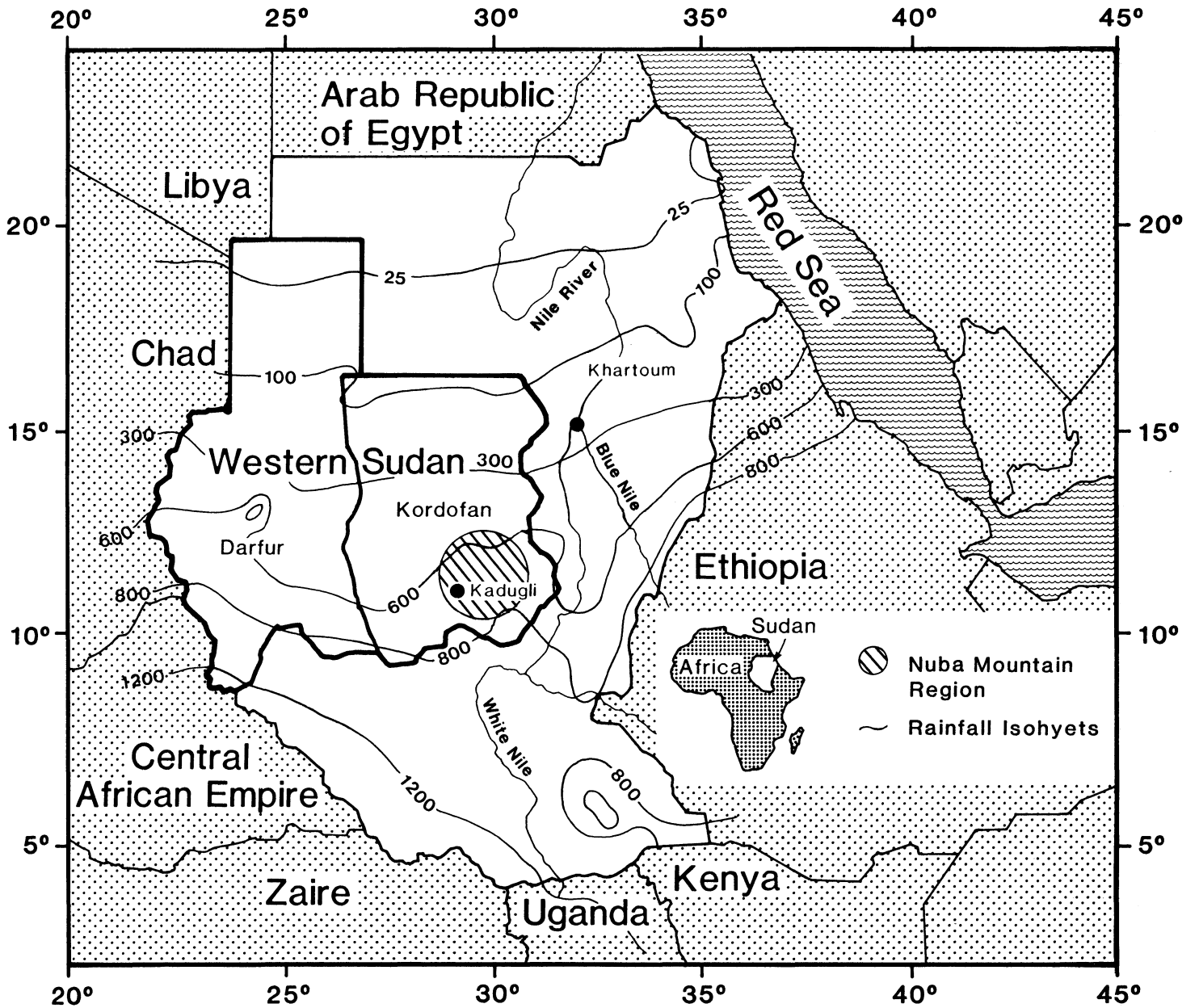

Figure 1 Location of Nuba Mountain Region with Mean Annual Rainfall for Sudan

TABLE 1: AGRONOMIC CHARACTERISTICS OF THE NUBA SEDENTARY SYSTEM

CHARACTERISTICS	JUBRAKA	NEAR FARMS	FAR FARMS
TOPOGRAPHY AND SOILS	Footslopes/hillside of sandy clays and loams adjacent to the household or its periphery	Footslopes/hillsides of sandy clays and loams generally less than 1-2 km away from household	Primarily cracking clay plains with some non-cracking soils. Located 1-10 km away, commonly 5-6 km
CROPS RAISED	Early-Maturing Sorghum Maize Red Peppers Millet Tomatoes Sesame Tobacco Squash Melons Okra Kerkede	Medium-Maturing Sorghum Sesame* (mixed/sole crop) Cowpeas* (intercrop) Groundnuts * Grown with sorghum	Late-Maturing Sorghum Sesame* (mixed/sole crop) Cowpeas* (intercrop) Cotton (mostly mechanized) * Grown with sorghum
AREA PLANTED	Less than 1/4 ha	1/8 to 1 ha	2 to 8 ha
PATTERN OF CULTIVATION	More or less continuous cropping made possible by annual applications of manure. Exhausted sites left fallow 5-15 years. Plots are usually fenced with thorn bush from the coppicing Ziziphus spina-christi tree		Bush-fallow system. Sesame or cotton 1st year then 5-10 years of sorghum, followed by 6-20 years fallow.
LAND PREPARATION	Weeding with short and long-handled hoes. Some brush/grass burning and rock clearing or stacking. Crude terracing with rock borders serves to contain runoff and prevent soil/manure loss during the rains.		New land cleared with axes and hoes. Brush and old grass burned to kill newly germinating weeds/seedlings
TIME OF PLANTING	Early to late June	Mid to late June	Late June to late July
TIME OF WEEDING	Late June, mid-July & mid-late August	Early-mid July and mid August	Mid July, late August, & sometimes late September
TIME OF HARVESTING	Early to late September	Mid September to early October	November to January
YIELDS OF MAJOR CROPS* (KG/HA)	Sorghum (500-800)---------- Sesame (300-500)----------	Groundnuts (400-700) Cowpea intercrop (50-100)-	---------- ----------
DISPOSITION OF CROPS	Mainly food subsistence prior to far field grain harvest. Some cash/barter.	Cash and current season consumption	Sorghum mainly for food. Others and surpluses for cash/subsistence.
LABOR	Mostly women, also children	Mostly women, also children	Adults of both sexes but dominated by men; some children

* Yields may increase by 50% in good years, and decreae by half or more in drought years.

TABLE 2: CRUDE PROTEIN CONTENTS OF COMMON CROP RESIDUES AND NATIVE PLANTS IN THE NUBA MOUNTAIN REGION COMPARED WITH CULTIVATED FORAGE

PLANT SPECIES	% CRUDE PROTEIN WET SEASON	DRY SEASON
Grasses		
Brachiaria obtusiflora*	5.68	3.45
Sorghum purpureo-sericeum*	4.47	3.14
Hyparrhenia pseudocymbaria*	8.30	2.99
Setaria incrassata*	6.63	2.66
Echinochloa pyramidalis*	6.17	2.91
Brachiaria xantholeuca	15.94	4.77
Dactyloctenium aegyptium	11.40	4.56
Setaria pumila	6.22	4.30
Aristida hordaceae	5.49	2.93
Hyparrhenia confinis	5.21	2.71
Forbs (present in wet season)		
Alysicarpus glumaceus	15.37	N.A.
Spermacoce chaetocephala	9.94	"
Zornia glochidiata	17.92	"
Ocimum basilicum	16.30	"
Rhynchosia minima*	7.72	"
Trees/Shrubs (leaves)		
Combretum hartmannianum	12.85	12.12
Albizia amara	16.87	13.60
Balanites aegyptiaca*	17.53	10.07
Acacia seyal*	17.00	13.32
Dichrostachys cinerea*	16.26	14.47
Ziziphus spina-christi	20.35	11.25
Cultivated Crops		
Sorghum residues (leaves)*	N.A.	3.42
" " (stalks)*	"	2.50
" " (leaves)	"	4.24
" " (shoot regrowth)	"	8.64
Sesame residues*	"	4.18
Cowpeas (pre-flowering)*	21.52	N.A.
" (pod stage)*	16.30	"
Mung Beans (flowering)*	16.67	"
" " (pod stage)*	15.57	"
Phaseolus trilobus (pre-flow)*	18.12	"
" " (flowering)*	15.50	"
Guar (flowering)*	20.21	"
Clitoria ternatea (flowering)*	19.01	"

* On cracking clays

Source: Bunderson (unpublished data)

TABLE 3: ESTIMATED COSTS AND BENEFITS OF COWPEA MONOCROPPING VS. IMPROVED AND TRADITIONAL INTERCROPPING WITH OX/CART TRANSPORTATION

ASSUMPTIONS: (1) 350-500mm effective rainfall; (2) improved cowpea variety; (3) sole cowpea yield/ha 300kg and 2 tons forage; (4) improved intercrop yield ha 600 kg sorghum, 150kg cowpeas & 1 ton forage; (5) trad. intercrop yield ha sorghum 600 kg, cowpeas 50 kg; (6) labor SL 1.20 man-day ; (7) 84/85 prices for sorghum, cowpeas, and forage

	PRODUCTION COSTS HA (SUDAN POUNDS)		
ACTIVITY	COWPEA MONOCROPPING	IMPROVED INTERCROPPING	TRADITIONAL INTERCROPPING
Clearing	13.20	13.20	13.20
Sowing	20.40	18.00	12.00
1st Weeding	45.60	45.60	45.60
2nd Weeding	21.60	21.60	21.60
Harvesting, gathering and threshing			
Sorghum	-	30.00	30.00
Cowpea Grain	36.00	18.00	6.00
Cowpea Forage	8.40	4.20	-
Transport to Household			
Oxen/Cart @ SL 9.07 day-1 over 5 yrs and 500 kg day-1	41.72	34.46	11.80
Fodder Storage @ 2 m-2 100 kg-1 over 3 years	15.35	7.68	-
TOTAL PRODUCTION COSTS	SL 202.27	SL 192.74	SL 140.20
OPPORTUNITY COSTS @ 25% INTEREST	15.52	13.14	-
TOTAL OVERALL COSTS	SL 217.79	SL 205.88	SL 140.20
BENEFITS (-seeds for sowing)			
Sorghum @ SL 1.20/kg		708.00	708.00
Cowpeas @ SL 1.70/kg	467.50	233.75	76.50
Forage @ SL 0.10/kg	200.00	100.00	-
TOTAL BENEFITS	SL 667.50	SL 1041.75	SL 784.50

TABLE 4: BENEFIT/COST ANALYSIS

PRODUCTION/HA	COWPEA MONOCROPPING	IMPROVED INTERCROPPING	TRADITIONAL INTERCROPPING
TOTAL COSTS	217.79	205.88	140.20
TOTAL BENEFITS	667.50	1041.75	784.50
NET BENEFITS	449.71	835.87	644.30
NET BENEFIT/COST RATIO	2.06	4.06	4.60
MARGINAL BENEFIT/COST RATIO (OVER TRADITIONAL INTERCROPPING)	-2.51	+2.92	-

TABLE 5: ON-GOING AND PROPOSED STATION AND ON-FARM TRIALS

EXPERIMENT AND PURPOSE	LEGUME SPECIES	SOWING DATES	ROW SPACING	PLANT SPACING
STATION TRIALS				
(1) Variety Tests for: Grain/Forage Yields; nodulation; resistence to drought, insects, & disease; and days to maturity	Cowpeas	Early July	50 cm	20 cm
	Mung Beans		40 cm	20 cm
	Guar		50 cm	25 cm
(2) Sowing Dates to determine optimum time of planting using well-adapted varieties	As above	15 day intervals from June 15-Aug.15	As above	As above
(3) Plant Spacing Trials to determine optimum spacing between and within rows (using well-adapted varieties)	Cowpeas	Early July	40,50,60	20,30,40
	Mung Beans		30,40,50	20,30,40
	Guar		40,50,60	20,30,40
(4) Intercropping Trials with sorghum to determine optimum spacing between intercrops where the legumes are planted between rows of sorghum	Sorghum	Early July	80,120	20,40,60,80
	Cowpeas		80,120	20,30,40
	Mung Beans		80,120	20,30,40
	Guar		80,120	20,30,40
ON-FARM TRIALS				
(1) Intercropping Year 1 using local sorghum with local and improved cowpeas in separate plots	Local Sorghum	Early July	traditional	traditional
	Local Cowpeas		between sorghum	30
	Improved Cowpeas		between sorghum	30
(2) Intercropping Year 2 using local and improved varieties of sorghum and cowpeas in separate plots	Sorghum	Early July	based on results of (4) above	based on results of (4) above
	Cowpeas			
(3) Intercropping Year 3 introducing mung beans and guar depending on outcome of taste/market tests	---Design dependent on results of above trials---			

FARMER PARTICIPATION

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AN EXPLORATORY STUDY OF FARMER PARTICIPATION IN THE FARMING SYSTEMS RESEARCH AND EXTENSION PROCESS

Vickie A. Sigman and Harold J. McArthur, Jr.

Many proponents of Farming Systems Research and Development (FSR&D)[1] agree that it is more than an alternative research strategy. It complements other research and extension approaches to development. Some suggest it is a development process that has its own philosophy, cultural assumptions, and evolving methodologies. While there appears to be little disagreement on FSR&D goals, there is some divergence of opinion on how to implement the process at the project level.

FSR&D is frequently characterized as farmer-based. Several assumptions underlie this characterization. First, it is assumed that by focusing on problems, opportunities, and constraints of small farmers, it is possible to design or adapt technologies and recommendations that better meet small farmer needs. Secondly, it is assumed that farmer participation in this focusing process is desirable (Byerlee & Collinson, et al., 1980; Gilbert, Norman, & Winch, 1980; Rohrback, 1981; Shaner, Philipp, & Schmehl, 1982; Zandstra, Price, Litsinger, & Morris, 1981).

Little is known about implementation of farmer participation at the field level. For example, most project reports target outputs with little mention of how local farmers are involved and what they contribute to project accomplishments. What is needed is documentation on how and to what extent FSR&D projects have been able to involve farmers in their research and extension efforts.

To begin this documentation and to explore farmer participation in farming systems type projects throughout the world, a survey of projects was conducted. The purpose of this paper is two-fold: to report and examine selected survey research findings and to stimulate further research on farmer participation in farming systems type projects.

RESEARCH DESIGN

Assumptions

This study is based on several assumptions. First, since farmer participation is an ideal of FSR&D, it is assumed that projects identified in some way with FSR&D are making some attempts to involve farmers. Secondly, it is assumed that the dominant vehicle for applying the FSR&D approach is a project and that participation occurs within the context of projects. Given these assumptions, the study focuses on farmer participation in a sample of existing projects.

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[1]FSR&D is used here to refer to farming systems type research and farming systems type projects in general, including such variations as FSR/E (Farming Systems Research and Extension) and FSAR (Farming Systems Approach to Research).

Research Questions

The research questions examined in this paper are:

1. To what extent are projects working with local farmers and other groups?

2. What is it that farmers do that describes farmer participation in projects?

3. What is it that farmers, communities, and team members do that contributes to farmer participation in projects?

4. What reasons are given to explain why farmers participate in projects?

5. What are some of the achievements of farmer participation in projects?

6. What are some of the key constraints to farmer participation in projects?

Instrumentation

A survey questionnaire was constructed, pilot-tested, and mailed-out in June 1985. A follow-up letter was sent approximately six weeks later.

Research Population and Sample

The projects selected for study, the research population, were those listed either in the 1984 Farming Systems Support Project (FSSP) Directory or in the 1984 FSSP Inventory listing of FSR/E projects. The Directory, developed in 1984 from materials submitted by FSSP Newsletter readers throughout the world and from the Inventory Listing, is an incomplete inventory of farming systems projects. Further, as stated in the Directory:

> ...there are undoubtedly projects listed in this directory which are not farming systems projects, even though they were submitted as such. Many of the projects included have FSR as only a component of a much larger and complex project. (FSSP Newsletter, 1984, p. 1)

Two additional qualifications were placed on the research population. Only those Directory and Inventory Projects providing the name and address of either a contact person or one or more team members were included in the population. Where a single contact person or team member was listed for multiple projects, these projects were counted as one for the purposes of computing the number of projects in the research population. Thus, 79 projects throughout the world represented the research population.

The research sample consists of those projects whose contact or team member responded to the survey questionnaire. Thirty-nine useable responses were received, representing a self-selected sample of 49%. It is assumed that survey responses represent the perception of the responding individual involved in the project surveyed. In reviewing the findings, it is important to keep in mind that characteristics of respondents may have influenced their

perceptions of farmer participation. The survey instrument did not control for respondent characteristics such as role within the project, length of service in the project, and knowledge of FSR&D.

GENERAL DESCRIPTION OF RESPONDING PROJECTS

Project Identification

Of the responding projects about three-fifths (24) were identified by survey respondents as specifically designed to implement an FSR&D approach. The remaining two-fifths (15) projects were not identified specifically as FSR&D projects. These latter projects were identified by survey respondents as: primarily commodity or crop focused but incorporate some FSR&D methodology (8 projects), FSR&D projects in principle but not in practice (2 projects), integrated rural development projects (3 projects), project designed to develop methodology for farmer participation (1 project), and a technology transfer project (1 project).

Location of Projects

The majority of FSSP Inventory and Directory projects are located in the developing world. This is reflected in Table 1 which shows the geographical distribution of responding projects.

Table 1. Location of Projects

Area	Number	Percent
Latin America and the Caribbean	15	39
Asia	12	31
Africa	10	26
U.S.A.	2	5
TOTAL	39	101%*

*Due to rounding.

Project Year and Duration

The responding projects have been in existence for one to ten years with four years as the mean and five years as the mode and the median. Slightly less than one-tenth of projects are in their first year of implementation. About two-fifths of projects are in the second, third, or fourth year of implementation. This suggests most projects have been in the field a sufficient time to consider farmer-based aspects of the project. The projected length of projects ranges from 3 to 15 years with a mode of 5 years and a mean of 6.4 years.

Project Affiliation

The projects are affiliated with a variety of institutions as shown in Table 2. The majority (over two-thirds) are affiliated with host country institutions. Of these, most are associated with research institutes or centers. About one-quarter of projects are affiliated with an International Agricultural Research Center. The remainder are affiliated with "Other Institutions".

Table 2. Project Institutional Affiliation

Institution	Number	Percent
Host country:		
Research Institute or Center	10	29
University	6	17
Ministry	8	23
International:		
Research Center	9	26
Other Institution	2	6
TOTAL	35	101%*

*Due to rounding

Project Level

Almost one-half of the responding projects operate at the regional level. An additional one-fifth are at the village level. National level projects account for another one-fifth of projects. The remaining one-tenth are focused at a specific level (e.g., specific agroecological areas, project-defined rural development area).

Project Focus

Historically, farming systems projects have focused primarily on agronomic crops. The survey data lend further support to this generalization. The highest percentage of projects, 41%, focus on mixed cropping systems. The remainder focus as follows: on a single commodity, 13%; on both cropping and livestock systems, 8%; primarily on livestock, 8%; on soil management, 5%; on watershed management, 5%; and on institution building, 3%. The remaining 18% report having other foci such as methodology development, technology transfer, farm machinery testing, and seed production and storage systems.

FARMER-BASED ASPECTS OF PROJECTS

Project Time Spent with Groups

Respondents were asked to estimate the percentage of time their project works with different groups of people. Table 3 shows that about one-half of

project time is spent working with local farmers. Approximately one-quarter of time is spent with national scientists while about one-tenth of project time is spent with extension agents.

Table 3. Project Time Spent With Groups

Group	Percent Time
Local Farmers	51
National Scientists	23
Government Extension Agents	12
International Agricultural Research Center Staff	8
National Planners	3
Others	3
TOTAL	100%

NOTE: No. of cases: 39.

Discussion

Local Farmers

Results show the highest percentage of time, 51%, is spent working with local farmers. Of these farmers, reported estimates indicate an average of 84% of local farmers are male and 16% are female. Across major geographical regions, percentages of male and female farmers that projects work with vary somewhat, but not to the degree that might have been expected given the importance of female farmers in certain areas of the world and in Africa in particular.

Government Extension Agents

Respondents reported that an average of 12% of project time is spent with government extension agents. This tentatively suggests that few projects are closely linked to government extension services, as measured by time spent working with agents. This raises the issue of whether projects should be working with extension services and agents. For example, how much time should projects spend with extension, doing what, for what purpose?

Theoretically, extension offers a linkage to local farmers. In FSR&D, there may be a need to study and design methodologies which strengthen farmer-based aspects of FSR&D by strengthening FSR&D linkages with extension. Conceptually, FSR&D includes linkages and interaction with extension.

> Throughout the research process, the FSR&D team maintains contact with support organizations in the area. Extension plays an especially important role in the process. Inputs from extension should occur at all levels of FSR&D-from

> initially identifying areas to the broad implementation of results. FSR&D practitioners generally recommend that the extension staff be trained in FSR&D and become regular members of the field and regional teams.
> (Shaner, Philipp, & Schmehl, 1982, p.6)

Work on the extension or the "/E" aspect of FSR/E has moved forward. Several papers presented at the 1983 and 1984 Farming Systems Research Symposiums considered extension issues. A specific example is Chamala's report on the integration of extension in FSR&D efforts to promote conservation cropping in Queensland, Australia (Chamala & Keith, 1984). Currently, Hildebrand (1985) is putting forward the concept of "diffusion domains". This concept builds on research and recommendation domains and focuses thinking on the process frequently referred to as extension. The focus of the October 1985 Zambia Research Extension Linkage Workshop was on systems evolving in Malawi and Zambia that in practice address the research/extension/farmer interface within FSR/E. This jointly sponsored workshop brought institutional attention to linkage issues.[2]

Operational Definition of Farmer Participation

To understand what constitutes farmer participation from the project perspective, the questionnaire asked: Which of the following best describes farmer participation in your project? Respondents are asked to rate a pre-selected set of variables (ways in which farmers might be participating) on a six-point Likert scale where:

0 = not applicable at all
1 = only minimally applicable
2 = not very applicable
3 = somewhat applicable
4 = generally applicable
5 = very applicable.

Results shown in Table 4 suggest that of the variables examined none are, on average, perceived as <u>very applicable</u> to descriptions of farmer participation in projects. This suggests variables not examined in the study may be better descriptors of farmer participation than those examined.

Of the variables examined, "farmers provide knowledge and experience that influences project/research strategies", most frequently best describes farmer participation in projects. This is followed by "farmers act as subjects of socio-economic study" and "farmers evaluate technology". The variables which do not seem to describe participation in projects include "farmers serve as members of project team" and "farmers provide hired laborers".

Within the framework of this study, the best answer to the research question "What is it that farmers do that describes farmer participation in projects?" is: "Farmers provide knowledge and experience that influences

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[2]Sponsors: International Program for Agricultural Knowledge Systems (INTERPAKS), University of Illinois and FSSP.

project/research strategies" and "farmers act as subjects of socio-economic study". A discussion follows of these and other variables reported in Table 4.

Table 4. Description of Farmer Participation

Description	Mean Score on Applicability Scale	(n)
Farmers:		
Provide knowledge and experience that influences project/research strategies	3.95	(37)
Act as subjects of socio-economic study	3.82	(38)
Evaluate technology	3.79	(38)
Receive improved technologies	3.62	(37)
Provide free labor/land	3.61	(38)
Manage on-farm trials	3.59	(39)
Respond to sondeo or rapid reconnaissance type needs assessment survey (also referred to as rapid survey variable)	3.42	(38)
Serve as members of project team	2.35	(37)
Provide hired laborers	1.76	(37)

Discussion

Farmer Knowledge and Experience Variable

The variable, "farmers provide knowledge and experience that influences project/research strategies", receives the highest mean rating of 3.95. Through what mechanisms are farmers providing this knowledge and experience? It does not appear that the suggested methodology for eliciting information from farmers, rapid surveys, is being used to influence project/research strategies because the "rapid survey" variable is viewed as only somewhat applicable to descriptions of farmer participation in projects.

The data suggest information from other types of socio-economic studies in which farmers participate may be influencing project/research strategies. This variable is further discussed below. Additionally, "farmers evaluate technology" appears to be an important source of farmer-based information that

may also influence project/research strategies. Questions for further study are: What communications in what contexts are being used by the team and by farmers for feedforward and feedback purposes? Or, through what mechanisms are farmers influencing project/research strategies? And, how can FSR&D teams create and/or strengthen these communications and mechanisms?

The Sondeo (Rapid Survey) and Socio-Economic Studies Variables

The variable, "farmers respond to sondeo or rapid reconnaissance type needs assessment survey" (referred to subsequently as "rapid survey"), receives a mean rating of 3.42. This suggests it applies somewhat to descriptions of farmer participation. The "rapid survey" variable describes farmer participation less well than those variables with higher mean ratings. In particular, "farmers act as subjects of socio-economic study" better describes farmer participation. This latter variable receives a comparatively high mean rating of 3.82 although it is also considered somewhat applicable to descriptions of farmer participation in projects.

There are a variety of types of socio-economic studies. It appears that farmer involvement in studies other than rapid survey studies better describes farmer participation than farmer involvement in rapid survey studies. This raises the following issues and questions.

Issues of Methodology

The FSR&D approach begins with teams aiding in the selection of both target areas and target groups of farmers and then dividing these areas into subareas according to common physical, biological, and socio-economic characteristics (Shaner, Philipp, & Schmehl, 1982). This process may be referred to as identifying recommendation domains and research areas (Byerlee & Collinson, et al., 1980). Specific problems, opportunities, and constraints are then identified within the context of these domains.

Information about the farming system is required to identify research areas and recommendation domains, to understand the farming system, and to identify problems, opportunities, and constraints. How are projects getting this information? The FSR&D approach suggests obtaining preliminary information through a review of secondary information and through direct observation of and discussion with members of farm households (Shaner, Philipp, & Schmehl, 1982, p. 28). In short, FSR&D suggests utilizing the rapid survey methodology to begin the FSR&D process and to provide the underlying basis of future directions.

The data suggest participation in rapid surveys is not a strong descriptor of farmer participation. Does this mean projects are not conducting rapid surveys? Or, perhaps it means that farmers are not participating in rapid surveys? Or, does it mean that surveys are being conducted and farmers are responding to surveys but this is not perceived as participation?

Projects surveyed have been in existence an average of four years. In many of the projects, rapid surveys may have been conducted sometime ago. Other types of farmer-based socio-economic studies may have followed these initial survey efforts. This offers another possible explanation for why the

rapid survey variable does not appear to be a strong descriptor of farmer participation in projects.

Questions for Consideration

In order to clarify the various possibilities, several questions need to be answered:

1. To what extent have projects, that are familiar with the FSR&D approach, institutionalized rapid surveys as a methodology for defining recommendation domains and research areas, for gaining understanding of farming systems, and for identifying farmer problems and opportunities?

2. Are projects applying other methodologies to collect this information and gain these understandings?

3. Are projects identifying domains, problems, and opportunities in the farmer context or are they initiating project work by applying previously conceived frameworks, solutions, and recommendations?

4. What is the scope of farmer participation in rapid surveys conducted by FSR&D projects?

5. What other types of socio-economic studies are being conducted in the field and for what purposes?

Support of Participation

At the project level, what do farmers, communities, and FSR&D teams do that is perceived as contributing to farmer participation? The questionnaire elicits responses to this question by asking: What major activities have contributed to farmer participation in your project? Variables are rated in importance on a six-point Likert scale where:

0 = not important at all
1 = only minimally important
2 = not very important
3 = somewhat important
4 = generally important
5 = very important.

Results in Table 5 indicate that "farmer asks to be involved in project" is considered as a somewhat important activity that contributes to farmer participation. "Community assigns farmers to project" is viewed as only minimally important.

It appears that several actions taken by team members are considered to be generally important. These are: "team explains project to local residents" and "team actively recruits farmers as project cooperators". As a method contributing to farmer participation, "team conducts a community level needs assessment survey" is viewed as between not very important and somewhat important. "Team hires farmers to work on project" does not appear to be viewed as a method that supports farmer participation.

Table 5. Actions Contributing to Farmer Participation

Action	Mean Score on Importance Scale	(n)
Farmer:		
Asks to be involved in project	3.36	(39)
Community:		
Assigns farmers to project	1.43	(37)
Team:		
Explains project to local residents	4.21	(39)
Actively recruits farmers as project cooperators	4.08	(38)
Conducts a community level needs assessment survey	2.84	(37)
Hires farmers to work on project	1.00	(37)

Discussion

It is particularly interesting that "community assigns farmers to project" is seen as an only minimally important way through which communities contribute to farmer participation in projects. Historically, projects work through local officials or community leaders to obtain village-level official sanction and as a means of contacting farmers. The data suggest that this does not contribute to farmer participation as much as may be expected. It may be that the wording of the questionnaire, "community assigns farmers to project", does not adequately capture the sense of the community-farmer-project linkages. "Assigns" may be too strong a word. For example, local leaders may suggest that certain farmers volunteer for participation in projects. And, project staff may view farmers as volunteering. However, from the perspective of the individual farmer, some elements of coercion or obligation to the local officials who suggested their names as cooperators may influence their willingness to participate in the project.

There may be a problem of terminology with the variable "team conducts a community level needs assessment survey". Rapid surveys are a type of community needs assessment. However, community needs assessments may also involve more in-depth, long-term investigation. It is not clear how respondents interpreted this variable. If they interpreted a community needs assessment as the same as rapid surveys, then the data suggest rapid surveys are not viewed as effective ways for team members to support farmer participation in projects.

Reasons for Participation

Farmers participate in projects for a variety of reasons. They may be seeking involvement because of certain perceived benefits or they may be actively recruited. Participation may be voluntarily or coercively induced and it may be mandated yet not realized. In this study, it is assumed that farmer participation is of a more voluntary than coercive nature.

To explore possible explanations for farmer participation, respondents were asked to rate the importance of selected reasons for sustained farmer participation in their projects. Importance is measured on a six-point Likert scale where:

0 = not important at all
1 = only minimally important
2 = not very important
3 = somewhat important
4 = generally important
5 = very important.

As shown in Table 6, "expectation of learning new methods to improve agricultural system and/or quality of life" appears to be perceived by respondents as the more important reason for sustained farmer participation. This receives, by far, the highest mean score (4.31). This is followed by "access to agricultural inputs", which is seen as between somewhat and generally important. Least important in explaining sustained farmer participation is "wages".

Table 6: Reasons for Farmer Participation

Reason	Mean Score on Importance Scale	(n)
Expectation of learning new methods to improve agricultural system and/or quality of life	4.31	(39)
Access to agricultural inputs	3.34	(38)
Prestige	2.55	(38)
A sense of obligation	1.82	(38)
Access to other benefits (transportation, first aid care, loans from project staff)	1.81	(37)
Wages	.92	(36)

Discussion

Reasons given for farmer participation are from the perspective of the responding project person. It would be interesting to compare these data with the reasons farmers give for their participation in projects. If farmer participation is indeed based on farmer expectations of learning, then it seems clear projects should focus on the learning/teaching aspects of their field work. For example, what do farmers learn from participating in socio-economic studies or from managing on-farm trials? Are there ways to increase farmer learning in these situations?

Project Achievements

What have FSR&D projects achieved with respect to farmer participation? Potential achievements were listed in the survey and respondents were asked to rate their importance, again on a six-point Likert scale where:

0 = not important at all
1 = only minimally important
2 = not very important
3 = somewhat important
4 = generally important
5 = very important.

The achievements considered generally important in projects are "project team members benefit from indigenous farmer knowledge" and "farmers are involved in on-farm trial management". These achievements receive mean ratings of 4.36 and 4.13 respectively as reported in Table 7. Involving actors other than team members and farmers in the project appears to be of lesser importance.

Discussion

Table 7 shows the variable, "project team members benefit from indigenous farmer knowledge" receives the highest mean rating. Clearly, there is some form of communication between team members and local farmers. As indicated earlier, the key question is what kind of communication under what circumstances is occurring. One hypothesis is that the team benefits from farmer knowledge because of the cumulative knowledge they gain from regularized, on-going contact with farmers. The data suggest that one aspect of this on-going contact is the two-way communication associated with the establishment and monitoring of farmer-managed trials.

"Farmers are involved in project design" is seen as only somewhat important. This might suggest that farmer input in the design process occurs in an indirect rather than a direct manner. For example, rather than scientists sitting down with a group of farmers to go over every aspect of a trial design, the researchers themselves may be making a series of changes or modifications based on information from farmers or from their own observations of what the farmers have and have not done during earlier trials. Such indirect transfer of knowledge may not be recognized as farmer input by the project team members.

Table 7. Project Achievements

Achievement	Mean Score on Importance Scale	(n)
Project team members benefit from indigenous farmer knowledge	4.36	(39)
Farmers are involved in on-farm trial management	4.13	(38)
Farmers are involved in project implementation	3.97	(38)
Farmers are involved in project design	2.92	(37)
National planners and scientists are involved in project implementation	2.90	(39)
National leaders and scientists are involved in project design	2.87	(39)
Creation of inter-agency support base for support of farmer participation	2.60	(37)

Project Constraints

Respondents were asked to rate selected factors which potentially constrain their project efforts to establish effective levels of farmer participation. Factors are rated on a six-point Likert scale where:

0 = not constraining at all
1 = only minimally constraining
2 = not very constraining
3 = somewhat constraining
4 = generally constraining
5 = very constraining.

The data in Table 8 indicate that none of the factors rated are perceived as either generally constraining or as very constraining. This suggests other factors not included in the survey may present greater constraints to establishing farmer participation than the factors considered.

Respondents reported that of those factors considered, the more constraining involve "institutional (political, administrative) barriers to bottom-up or grass-roots development". This factor receives the highest mean rating of 3.26 and is seen as a somewhat constraining factor. This is closely followed by "insufficient training for project team in concepts and methods of participatory development", also viewed as somewhat constraining.

Table 8. Description of Constraints to Farmer Participation

Description	Mean Score on Constraint Scale
Constraints:	
Institutional (political, administrative) barriers to bottom up or grass-roots development.	3.26
Insufficient training for project team in concepts and methods of participatory development.	3.00
Lack of understanding and support of the FSR approach at the national level.	2.39
Communication problems between project staff and local community.	2.23
Distance of research site from impact area.	2.05
Communication problems among project staff.	2.05
Lack of appreciation by team members of value of local participation.	1.80

NOTE: No. of cases: 39

Discussion

The institutional factor suggests that establishing farmer participation in projects involves elements that are external to projects. This relates directly to what has been referred to as FSIP (Farming Systems Infrastructure and Policy), an aspect of the farming systems process that has received very little attention.

Institutionally, what might constrain farmer participation in projects? A consideration may be the very concept of projects. The FSR&D approach assumes the research and extension process begins with an assessment of local-level needs, constraints, and opportunities. This base is then built upon in a way that addresses farmer needs by producing solutions that farmers can adopt. All of this is supposedly done within the context of a project. However, projects are not designed and funded in a vacuum. Funds are seldom allocated to support yet to be defined research objectives. Rather, projects are most frequently designed in advance to meet a range of national and international concerns. Hence, it may be exceedingly difficult for projects to actually begin with and build from an assessment of farmer-based problems.

A further element contributing to institutional barriers may relate to cultural conflicts. Wilson, Philipp, Shaner (1985) suggest that there are

certain cultural assumptions embedded in the FSR&D process that are not shared universally and may at times be in conflict with institutionalized indigenous values and government policies. For example, FSR&D is designed as a bottom-up process based on the premise that farmers can and should be involved in the development process. This premise is egalitarian in nature and assumes that farmers are indeed intelligent and capable of contributing useful ideas and knowledge. However, this may be counter to the traditions and policies of centralized governmental systems that wish to focus on but not necessarily involve farmers in development.

"Insufficient training for project team in concepts and methods of participatory development" is viewed as a somewhat constraining factor. It may be there is a need to increase team members skills in these aspects of the FSR&D process. The level of previous training in the participatory aspects of the FSR&D process and, in general, the level of previous training in FSR&D methodology overall, may account for variation in the manner and degree to which FSR&D teams are able to apply the approach in the field.

SUMMARY

This paper reports selected survey data from a self-selected sample of farming systems type projects. It examines aspects of farmer participation in these projects.

Data from this study suggest that field projects identified with FSR&D are indeed working with local farmers. Given a number of potential client groups, projects report that on average, over one-half of project time is spent working with local farmers. It does not seem that projects are fully utilizing the potential opportunity to work with extension agents as a complementary way to reach local farmers. Projects report that on average, about one-tenth of project time is spent working with extension agents.

Based on data from this study, the best way to describe farmer participation in projects (from the project's perspective) is: "Farmers provide knowledge and experience that influences project/research strategies". This variable is seen most closely as generally applicable to descriptions of farmer participation in projects. Also, the study shows that "team members benefit from indigenous farmer knowledge". This variable is rated as the most important achievement projects have realized with respect to farmer participation. It is perceived as a generally important achievement.

One of the more interesting and perplexing findings of this study is that farmer involvement in sondeos or rapid surveys does not appear to be a strong descriptor of farmer participation in projects. The FSR&D approach suggests that data from these types of studies be used to help in designing projects. Given this and the overall importance that FSR&D places on understanding local farming systems, it is surprising that sondeos or rapid surveys are viewed only as somewhat applicable to descriptions of farmer participation. Sondeos or surveys may play less of a role than expected in the design process--the process through which teams learn about local farm conditions and apply this data to project design. However, projects report that institutional barriers to bottom-up development somewhat constrain their efforts to establish effective levels of farmer participation in their projects. Many projects are

tightly designed before they are put in place in the field. This may explain some of the perplexity surrounding the sondeo findings. Or, it may be that because projects surveyed are, on average, in their fourth year of implementation and as surveys are often conducted early-on in projects, the importance of the exercise has been forgotten.

The data indicate that "farmers are involved in on-farm trial management". This is viewed as between somewhat and generally applicable to farmer participation in projects and is seen as one of the more important achievements projects have reached with respect to farmer participation. As a way to describe farmer participation in projects, "farmers evaluate technologies" is also reported as one of the better ways to describe their participation. The FSR&D literature suggests farmer-managed trials are a part of the technology verification and evaluation process. Thus, it seems that farmers managing on-farm trials is a critical way in which projects work with farmers on farmer fields and it is an important way in which farmers contribute to project implementation and evaluation.

Respondents suggest the key reason for sustained farmer participation in their projects is the farmers' expectations of learning new methods that will improve their agriculturally-based livelihood. This expected learning may be seen by farmers as a potential benefit resulting from their participation in projects.

THOUGHTS FOR FUTURE CONSIDERATION

The data clearly suggest that farmers are involved in FSR&D projects but the precise nature and value of this involvement varies and is likely influenced by a range of factors. We know from the survey data that farmers are involved in providing knowledge and experience that influences project and research strategies. The specific nature of their involvement is beyond the scope of this study and will require further investigation.

For example, as part of an interdisciplinary farming systems team, individual team members are exposed to a range of data and ideas. Under such conditions, learning is taking place in a way that to pinpoint the exact source of data and ideas may be difficult. In addition to the source of information (trial results, observations, survey findings, informal interviews) the process by which team members analyze, interpret, and act upon new knowledge must be considered. A particular comment made by a farmer, or something observed by a researcher, may be introduced to the team and discussed in a way that leads to some refinement or modification in the research design. It is not clear to what extent the end result of this process is perceived by team members as an example of farmer involvement in research design and/or evaluation.

It is apparent that "project team members benefit from indigenous knowledge". What we do not know, and what this study did not ask, is what kinds of insights are being gained through interaction with farmers. On the other side, the survey data suggest that team members perceive that farmers are motivated to participate in projects because of the benefits they expect to receive from improved agricultural methods. This suggests that farmers may feel that they will learn something from interacting with researchers and from participating in project activities.

Team member and farmer learning are assumed to be part of the FSR&D approach, but they have not been examined in any detail. An understanding of this complex process, and the theoretical assumptions and methodologies that underlie it, may be one of the most important and far reaching contributions that farming systems research can make to agricultural development. If we can learn how teams obtain and interpret indigenous knowledge and how farmers learn from their experience as project participants, we will be able to develop and refine better methodologies to bring us closer to an agricultural development process that is truly a collaborative effort between researchers, extension agents, and farmers. A better understanding of the farmer learning process may also provide a base for developing ways to involve extension more directly in the FSR&D approach.

Extension involves communication: providing information to farmers and teaching them how to do things better. Ideally, extension is an educational process. There is a direct relationship between teaching and learning. If recommendations are presented in a way that is inconsistent with the manner in which the audience or client group processes information, little learning and adoption is likely to occur. Both researchers and extension agents could benefit from research that leads to a a better understanding of how farmers perceive and interpret new information and in what contexts they learn and transmit knowledge. Likewise, both researchers and extension agents may benefit from a better understanding of their own learning processes and how they receive and process information from each other.

It is important to focus both on what is working and what is not working in FSR&D. Teams are benefiting from farmer information so something about the process is working. On the other hand, there are various factors that make it difficult to fully implement the FSR&D approach. It would be useful to look for better ways to identify and understand the various barriers that constrain farmer participation.

The survey data indicate that perhaps the factors that pose the greatest obstacle to successful implementation of FSR&D efforts vis-a-vis participation are variables other than those explored in the study. Of those factors examined in the survey, the most constraining involves institutional barriers to bottom-up development. This study did not attempt to discern the nature of institutional barriers. More research needs to be done on these constraints to farmer participation and how they can be better dealt with. Particular attention to what has been labeled Farming Systems Infrastructure and Policy is required.

It has been suggested (Wilson, Philipp, & Shaner, 1985) that one factor that may contribute to institutional barriers is cultural conflict. Inherent in the FSR&D process are certain cultural assumptions concerning equity, the role of farmers, and the goals of development in general. Not all assumptions are universally shared. It is quite possible for a centralized government agency to wish to focus research on farmers without involving them directly or otherwise in any of the planning or decision-making processes.

Another important factor that should be looked at in relation to institutional constraints is structure. This study is based on the assumption that the development project is the dominant vehicle within which most, if not all, FSR&D takes place. Projects are organizations created by individuals to

serve a number of groups: research, extension, and project staff; implementing and funding agencies; and ultimately, the identified client group. Before a project is approved for funding and implementation, it must be designed in a way that is consistent with the objectives and needs of the sponsoring and administrative units. Sometimes the objectives of these groups, as articulated in the project structure and design, make it very difficult to adhere to the farming systems precept of beginning with, involving, and ending with the farmer. Further research on new or alternative approaches to project design might reduce the range of institutional constraints faced by projects and might result in projects that more effectively utilize farmer knowledge to reach project goals and objectives.

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FARMER PARTICIPATION IN ON-FARM TRIALS

Clive Lightfoot

That farmer participation is mandatory to quality Farming Systems Research few would deny. Indeed, farmer participation as expressed in models of farmer-first-and-last and farmer-back-to-farmer, dominate our rhetoric. But it is also a very different way of doing agricultural development research. Achieving such, necessitates intimate farmer involvement in processes of understanding existing systems, diagnosing their problems, designing solutions, and testing them. In method development considerable strides have been made to involve farmers in understanding systems and in diagnosing problems. Unfortunately, on-farm testing did not receive such attention. Researchers simply transplanted conventional 'on-station' research designs onto farms.

Conventional designs hinder meaningful farmer participation. Previously I talked about weakness of farmer participation inherent to complex trials (Lightfoot, 1984). At that time I stressed that complex treatment structures and layouts are hard for farmers to understand and implement because they are foreign to their experience. This opens the door to many potential errors. I gave examples of how misunderstood implementation can result in lost data, a considerable risk when only a few experiments can be established. I gave examples of how necessary experimenter planting causes many logistical difficulties that can result in confounding the treatments. Another interesting source of confounding arises from relationships between degree of farmer participation and treatment yields. It has been found that treatment yields fall with increasing farmer participation; thus, conclusions about treatment performance diverge "substantially" depending on the level of farmer participation (Ashby, 1984). There are also many socioeconomic considerations. For example, because of the excessive area required cooperators tend to be larger farmers not representative of the resource poor farmer target group (Kirkby et al., 1981).

Difficulties such as these lead many to believe that simple indigenous farmer research designs could be a valuable resource for developing on-farm experimental methods, particularly, for adapting technologies and providing feedback on basic research needs (Biggs, 1980). Some go so far as to say that getting farmers to design and manage trials can, "..qualitatively improve information feedback from farmers to researchers about how to evaluate technology, and can materially improve the effectiveness of on-farm testing in identifying new technical options for the small farmer consistent with the value judgments farmers themselves make about innovations." (Ashby, 1984). Indeed, as Gilbert, Norman and Winch (1980) note, "The concept of FSR explicitly recognizes the value of the farmers experience and their traditional experimentation as inputs into developing strategies for improving the productivity of existing farming systems.". Moreover, there is a trend away from complex experiments and towards smaller less formal simple experiments; finding that this removes the bias of large trials to larger farmers, and increases farmer participation to improve interpretation of results and feedback of future research needs (Kirkby et al., 1981).

Farmers understand the concept of experimentation, and that there is no lack of indigenous research. In support of this contention Johnson cites many instances of farmer experimentation including H.Conklin's 1957 classic on Hanuoo agriculture in the Philippines. Conklin witnessed that, "cultigens of all sorts especially new or unfamiliar varieties are grown experimentally in small homeyard gardens as single objects of great horticultural interest." (Johnson, 1972). Moreover, Richards (1981) found that in rural Sierra Leone there was no lack of indigenous research and farmers understood the idea of controlled input-output trials. He even went on to say "..that expensive supervised on-farm trials for demonstration purposes are unnecessary." It was also Biggs' (1980) experience that agricultural communities in Bangladesh operate a dynamic and productive informal research system that interacts with any new technology introduced from outside. He went on to say that farmers try out new practices such as fertilizer use on small plots next to their own normal crops, which he equated to researchers' simple yes/no trials. Furthermore, indigenous research systems have generated viable technologies: one striking example for its dramatic impact in Bihar, India, was the farmer development of a bamboo tube well (Dommen, 1975).

Farmers feedback can improve basic research. Brammer (1984) describes how farmer research, carried out by the farmers themselves, exposed the importance of blue-green algae as a source of nitrogen for seasonally flooded rice. Similarly, Ashby (1984) found that farmer participation in Phosphate fertilizer trials produced feedback that led to new basic research, "..because new questions were raised about the chemical reactions of rock phosphate with organic fertilizers and in mixtures with conventional Phosphate sources.".

All this is not to say that complex experiments to unravel biological responses are not needed rather, that they are difficult to conduct inside the concepts of FSR. One often hears of researchers removing farmers completely so that variation can be controlled and treatment effects detected. It maybe research, but is it FSR? This paper argues that combining conventional and indigenous research methods exploits farmer participation in roles of: (1) adapting technologies to specific farm conditions; and (2) providing feedback on more appropriate basic research needs. In the former case a farmers' experiment in the adaptation of upland rice to lowland conditions will be examined. In the latter case, a farmers' evaluation of sweet potato varieties will be examined.

THE STUDIES

In regard to these two roles, farmer adaptation and feedback to basic research, The Farming Systems Development Project, Eastern Visayas (FSDP-EV) has had interesting experiences with farmer adaptation of an upland or dryland rice variety to lowland flooded conditions, and farmer evaluation of sweet potato varieties giving rise to new breeding objectives. I use the term experience rather than experiment because the work was rather informal and after the event. Nevertheless, both experiences showed us methods worth building on in the future.

In the case of farmer adaptation, the problem they wished to solve arose as a consequence of flash flooding during November 1983 that destroyed much of their lowland bunded rice crop. This destruction left their seed supplies of conventional lowland varieties, IR36 and IR42, short. To solve this problem of inadequate seed farmers decided to try the upland rice variety UPL-Ri5, that had grown poorly in their FSDP-EV experimental upland plots, in their lowland bunded plots. UPL-Ri5 was also obtained from other farmers and from a Ministry of Agriculture and Food relief effort. Because these farmers were selected for their adaptation "experiment" in lowland areas, they are not typical of our 'small upland rainfed' target group. Half of the farmers did not have any upland parcels at all. Notwithstanding, they could still be described as 'small'. Incomes were derived mainly from farming just under one hectare of lowland. Forty percent of the farmers had title to this land while the remainder were sharecropping. In addition, half the farmers had one hectare of upland which 90% of them had some kind of title. How to adapt this upland variety and what its performance would be like were the central research questions these farmers sought to answer.

To adapt upland rice to lowland conditions farmers generally followed lowland rice husbandry practices shown in Table 1. With the exception of one farmer who grew his crop during the upland season of May to September because he did not get seed on time, upland rice was grown during the traditional lowland rice season of December and April. Transplanting dominated the planting technique with about half the farmers planting wetbed and half drybed. Similarly, on all plots between four to five plants were randomly planted on each hill at about 15 to 20 cm apart. Thus, plant populations ranged from 100 to 220 m-1, more than twice the typical upland plant populations. Other husbandry practices rarely differ between locations, for instance, no fertilizer was applied and weeding practices varied from none to twice.

Generally, farmers assessed UPL-Ri5's performance to be comparable with lowland varieties IR36 and IR42. Specifically, for production aspects, shown in Table 2, farmers noted that UPL-Ri5 produced from 6 to 10 tillers which is less than the IR's, and a disadvantage of this upland variety. All farmers commented on the favorability of UPL-Ri5's good panicle exertion for judging ripeness and yield; except for its susceptibility to bird damage if it is the only crop around. Again, all farmers reported good head fill except one farmer whose crop was damaged by flooding after flowering. Maturity periods between three and five months were comparable with IR36's three months and IR42's four months. In terms of grain yield, a comparison of farmers estimated actual yields of UPL-Ri5, while farmers expected yield of IR36 and IR42 showed no significant differences (mean difference of 192kg ha-1 with 't' of 1.29 at df.11). Indeed, there was a great deal of overlap in likely yields; for instance, at 80% confidence level UPL-Ri5 yields range from 3.4 to 2.6 t ha-1 while IR expected yields range from 3.2 to 2.5 t ha-1. From the stability point of view all farmers agreed that UPL-Ri5 can tolerate weeds and is a better competitor than the IR's because of its taller habit. In addition, most farmers, even though they observed no diseases, think UPL-Ri5 is strong. Significant here was the absence of Tungro to which UPL-Ri5 is reported susceptible. Of the farmers who did experience pests they said UPL-Ri5 tolerated the attacks. Farmers

also included milling recovery, cooking quality, and palatability in their assessment. All farmers agreed that UPL-Ri5 had a high, some said very high, milling recovery that was superior to the IR's. Farmers also agreed that UPL-Ri5 had a good sticky cooking quality and was soft and palatable. On balance, these largely favorable assessments were supported by continued use or adoption of UPL-Ri5 in lowland bunded conditions. However, farmers defined specific strategies for this practice. UPL-Ri5 is grown in rotation with IR's because farmers note declining yields when the same variety is grown continuously on one piece of land. UPL-Ri5 is grown on the driest parts of the parcel because it is less tolerant of waterlogging than IR's.

This kind of farmer adaptation is probably quite common. Several people have recounted similar experiences from elsewhere in the Philippines. It is certainly similar to that reported by Biggs (1980) who found that, "after official demonstrations were made in farmers fields to show the potential of the new seeds, often under optimal or high input conditions, it was frequently the farmers themselves who adapted those packages to their own conditions.". Still, farming systems researchers have yet to exploit this or build on-farm experimental methods around it.

Turning from adaptation to the role of providing feedback on basic research brings us to our farmers' evaluation of sweet potato varieties. Here, however, farmers had several reasons for growing different varieties beyond evaluation. They were also maintaining lines and a drought in mid 1983 left them unusually short of planting material most especially as a recent typhoon had destroyed many crops. So they planted whatever varieties they could find. Our purpose was to follow up on what varieties were grown, what evaluation criteria were being used, and how varieties were assessed. This was of particular interest as all 12 farmers had received from the Project at least one improved variety. These farmers, even though they differed in key characteristics, could still be considered within the 'small upland rainfed' target group. For instance, although cultivating one upland hectare was typical, areas varied from a 1/4 to 7 ha. Half the farmers had no lowland areas while the remainder had slightly less than 1 ha. Even though half the farmers were tenants and half were owners, farming supplemented by casual laboring provided most of their cash income.

In all, 16 varieties were grown, though most farmers only grew 6 of them. These they described by leaf shape and color, and color of tuber skin and flesh. As shown in Table 3 each variety was unique. Leaves were red and/or green, heart shaped or irregularly tri lobed, digitate, or triangular. Tuber skin and flesh colors were white, yellow, or orange, except for some skins which were red.

While there was hardly any variation between farmers in the way they described varieties variations in evaluation were more numerous, as shown in Table 4. Farmers evaluate varieties by: taste, preferring sweetness and dryness; ability to store for long periods in the soil without rotting; maturity period being preferably short; high yield and large tuber size; pest and disease tolerance, particularly for weevil; rapid vining to cover the soil; and long duration of harvesting. Thus, we find the farmers' top staple and marketed varieties, Karingkit and Kadulaw, have a good sweet dry taste, high yield class of large 10 cm diameter tubers, and rapid vining covering

the soil in one to two months. In addition they can be harvested for up to one year because they store well in the soil, not easily being attacked by weevil. Long maturity period is their main disadvantage. Conversely, the improved VSP-1 and -2 have considerable disadvantages in the inability of their vines to cover the soil, their short harvesting period, and their sweet wet taste which only has snack value. The most significant implications of this work is that conventional breeding objectives of high yield with long maturity periods, sweet taste, and single harvest are inappropriate. Indeed, farmers demand both different breeding objectives and a greater range of types for the many different strategies they have. They seek rapid vining to suppress weeds and reduce soil erosion, prolonged sequential harvesting with good production off the vine, and weevil tolerance during underground storage. Nevertheless, at times of calamity they are prepared to compromise taste and yield for short maturity.

Again, this kind of farmer 'experiment' is probably not uncommon. Johnson (1972) noticed in Northeastern Brazil several cases of experimentation among illiterate swidden farmers: "One old man was experimenting with a new strain of manioc he had received from a friend living somewhat distant: he had set aside a small portion of a manioc field to test the new variety..". Still, farming systems researchers design, manage and implement their own on-farm variety trials without turning to see what farmers are doing.

A NOTE ON METHOD

Having farmers dominate experiments leaves researchers with a different set of activities. Both these pieces of work went through three activities. First, research topics were detected by informal consultations and observations. In the case of the sweet potato work many different varieties were seen on one farmers lot, and he was questioned why he was growing so many different types. Similarly, UPL-Ri5 was seen growing in bunded plots and farmers were questioned. After the discovery on one or two farms more farmers were questioned to determine if such practices were widespread and worthy of study. It was at this time that connections were made with Project provision of planting material as relief from floods in one case and typhoon in the other. Due to the nature of our experiences, identification of cooperators and provision of planting material, our second activity was largely 'unconscious'. That is, planting materials were distributed as part of another effort and cooperators were those who engaged in adaptation or evaluation. In future work, however, factoring in farmer typology when selecting cooperators would be included in this important second activity. The third and last activity was to develop and administer an informal survey using a checklist to guide the dialogue. Checklists provided guidelines for gathering information on farmer typology, nature of problems or farmer purpose, description of practices, and farmers' assessment. Several farm visits were required to gather all the information. Unfortunately, our late timing did not permit any biological measurement to corroborate the farmers' assessment; something that would be included in any improved method. These activities are not given as finalized methods but more a place to begin to combine indigenous and formal research methods that adapt technologies on farms and provide feedback on basic research needs.

CONCLUSION

Even though our methods were mainly descriptive and sometimes superficial researchers and farmers gained new knowledge. We now know how to grow UPL-Ri5 in bunded lowland conditions such that its performance is comparable with IR36 and IR42. We now know VSP's inadequacies in taste, vining habit, underground storage, and duration of harvesting. Furthermore, researchers now know that vigorous vining, extended underground storage, and sequential harvesting are important breeding objectives if varieties that better meet farmers needs are to be produced. The questions to be asked are: Can we now think of dropping formal randomized block trials as farmers have methods for looking at and adapting technologies which are far more comprehensive than conventional methods? Can we now think of no need for formal screening as farmers have techniques that are far more comprehensive than conventional on-farm variety trials that only assess plant habit and yield? Can we just give the planting material or train for a practice to the farmers, monitor what they do, measure some biological parameters, and consult them on assessment? The answer is probably not while there are still outstanding problems with using indigenous experimentation. For instance, farmer knowledge is hard to elicit. This will require researchers to develop new skills and new procedures for documentation and interpretation. In addition, indigenous experiments are slow. This will require researchers to facilitate, risk sharing on inputs and time, replication across farms for quick definite answers, and transfer of answers and ideas to increase farmers' technical options. Difficult though these tasks maybe, others urge as I do, for researchers to seek solutions in an optimum mix and balance between farmer and researcher participation using indigenous and formal techniques rather than a choice of either or (Howes and Chambers 1979).

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Table 1. How farmers adapted UPL-Ri5 to bunded conditions.

FARM	PLANTING METHOD	PLOT SIZE(ha)	SPACING (cms)	PLANTS /HILL	WEEDING	FERTILIZER
1	T.DRY	.11	15-20	4-5	2x	none
2	T.WET	.22	15-20	4-5	1x	none
3	T.WET	.25	15-20	4-5	1x	none
4	T.WET	.49	15-20	4-5	1x	none
5	D.DRY	.24	15-20	3-4	1x	none
6	T.WET	.22	15-20	4-5	none	none
7	T.DRY	.44	15-20	4-5	1x	none
8	T.DRY	.11	15-20	4-5	none	none
9	T.DRY	.05	15-20	5	none	none
10	T.DRY	.11	15-20	4-5	none	none
11	T.DRY	.49	15-20	4-5	none	none
12	T.WET	.44	15-20	3-4	none	none

PLANTING METHODS: Transplanting (T) in either dry or wetbeds, and direct seeding (D).
SPACING: Random at approximate dimensions given.

Table 2. How farmers assessed UPL-Ri5

FARM	1	2	3	4	5	6	7	8	9	10	11	12
TILLERING	6-10	L	L	L	6-9	8-10	L	8-10	L	L	8-10	8
PANICLE EXERSION	OP	OP	OP	OP	OP	OP	OP	OP	OP	OP	OP	OP
HEAD FILL	GO	GO	GO	GO	GO	GO	GO	GO	GO	GO	GO	PO
MATURITY PERIOD (mo)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	4.0	3.5	3.5	4.0
ACTUAL YIELD(t/ha)	1.7	3.1	3.7	2.1	3.8	3.8	2.6	2.7	3.3	5.1	3.4	1.5
EXPECTED YIELD(t/ha)	1.9	2.1	3.0	2.1	2.9	3.8	2.2	2.7	2.9	5.1	3.4	2.4
WEED TOLERANCE	GO	GO	GO	GO	GO	GO	GO	GO	GO	GO	GO	GO
DISEASE RESISTANCE	NO	NO	NO	YES	NO	NO	NO	NO	NO	YES	YES	NO
MILLING RECOVERY	HI	VHI	HI	VHI	HI	HI	HI	HI	HI	HI	HI	HI
COOKING QUALITY	ST	ST	ST	ST	ST	ST	ST	ST	ST	ST	ST	ST
PALATA -BILITY	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO

TILLERING (L) less than IR's. PANICLE EXERSION (OP) open display. HEAD FILL (GO/PO) good/poor. WEED TOLERANCE (GO) good can stand weeds. DISEASE RESISTANCE (NO/YES) to infestation. MILLING RECOVERY (V/HI) higher (very) than IR's. COOKING (ST) sticky, PALATABILITY (SO) soft.

Table 3. Sweet potato varietal characteristics

VARIETIES	LEAF		TUBER	
	SHAPE	COLOUR	SKIN COLOUR	FLESH COLOUR
KAAPOG	TRIANGULAR	RED	WHITE	WHITE
KANGISI	HEART	RED & GREEN	RED	WHITE
KASIMA	HEART	RED,d	RED	YELLOW,d
BNAS 51	HEART	GREEN & RED	WHITE	YELLOW
KADULAW	LOBED	RED & GREEN	WHITE,ORANGE	WHITE,ORANGE
KABUSAG	LOBED	GREEN	WHITE	WHITE
VSP-1	HEART	GREEN	YELLOW,ORANGE	YELLOW,l
VSP-2	DIGITATE	RED	ORANGE	ORANGE
INALEGRIA	HEART	RED	RED	YELLOW,l
INANAHAW	HEART	RED	WHITE	YELLOW
KAULPOT	TRIANGULAR	GREEN	RED	YELLOW,l
KASAPAD	HEART	GREEN	YELLOW,l	YELLOW,l
BINASAYNON	HEART	RED,d	RED	WHITE
KARINGKIT	LOBED	GREEN	WHITE	YELLOW
BANO	HEART	GREEN	WHITE	YELLOW
KAMAMON	LOBED	RED,l	ORANGE	ORANGE

for COLOURS: ,d = DARK, ,l = LIGHT

Table 4. Farmers' assessment of sweet potato varieties

VARIETY	TASTE	STORAGE IN SOIL	MATURITY PERIOD (mth)	YIELD CLASS	VIN-ING (mth)	DURATION HARVEST (mth)	TUBER SIZE (cms)	PESTS WEEVIL
KAAPOG	NS/D	GOOD	4,6-7	2,3	2,3	7-8	4,6-8	RES,SUS
KANGISI	S/D,W	POOR	3-5	2	1-3	2,7-8	4-8	RES,SUS
KASIMA	S,NS/D,W	POOR,GOOD	3,4	1-3	1-3	4-8	6-10	RES,SUS
BNAS 51	S	GOOD	4-5	2	0	7-8	6	SUS
KADULAW	S/D	GOOD,POOR	3-5	1,2	1-3	7-8,12	6-10	RES
VSP-2	S/W	GOOD,POOR	2-3	2-4	0	1,2	4-8	SUS
KABUSAG	S/D	POOR	7	2	1	12	6	RES
VSP-1	S/W	GOOD,POOR	2-3	2,3	0	1	5-6	SUS
INALEGRIA	S	POOR	2	3	2	2	3-4	SUS
KAULPOT	S/D	GOOD	2-3	2	1	7-8	5-6	SUS
KASAPAD	S,NS/D	GOOD,POOR	3-4	3-2	1,2	2	4-6	SUS
KARINGKIT	S/D	GOOD	4-7	1	2	12	10	RES
BINASAYNON	S/W	POOR	3-5	2,3	1	5,8	6-8	SUS
KAMAMON	S/D	GOOD,POOR	3-5	2	2	2,8	5-6	RES,SUS
INANAHAW	NS/D	GOOD	4-6	2	2	12	6-8	RES
BANO	NS/D	GOOD	4-5	2	1	8	6	RES

TASTE: S=SWEET (N)NOT, D=DRY, W=WET. STORAGE: GOOD/POOR=EASILY ROTTING.
VINING: TIME TO COVER GROUND. TUBER SIZE: DIAMETER.
PESTS: RES=RESISTANT SUS=SUSCEPTIBLE TO WEEVILS.

FARMING SYSTEMS RESEARCH AND EXTENSION IN HARSH ENVIRONMENTS: DEVELOPMENT OF A FARMER COOPERATOR APPROACH IN BOTSWANA

By
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INTRODUCTION

On-farm research programs following a farming systems (FS) approach have proliferated rapidly during the past five to ten years. Most ministries of agriculture of low income countries have one or more FS projects and many have begun to institutionalize national FS programs. This is true, for example, in southern Africa, largely as a result of an active CIMMYT training program under the leadership of Michael Collinson. As in southern Africa, international centers such as CIMMYT, ICRISAT and IRRI have played leading roles in developing and teaching FS work methods.

The rapid growth of the FS approach can be traced to many causes, including:

(a) Dissatisfaction with returns to investments in traditional agricultural research programs;
(b) Increasing concern with food production shortfalls and national food security;
(c) Inflated expectations concerning green revolution changes through modest investments of research and extension resources in farm system diagnosis and on-farm trials; and
(d) Substantial subsidies of FS programs through bilateral aid and from international donor agencies.

Not surprisingly, more has often been asked asked of FSR&E in national programs than had been the case at the international centers (Norman and Baker, 1984). On-farm research in national programs often is expected to contribute to national planning and to achievement of food security and equity objectives, as well as to the standard FS objective of increasing farm resource productivity through technological changes.

Over the last two years, we have noted a growing skepticism among development specialists and donor agencies about the potential of the FS approach. USAID, for example, is planning to revamp their African program by concentrating agricultural research resources on a few major food commodities emphasizing countries already having substantial investments in agricultural research. One of the main rationales presented in the USAID plan is the need for strong commodity based research (Agency for International Development, 1985). It is inevitable therefore that USAID support for FS projects in Africa will decrease.

We are concerned that the FS approach may be abandoned prematurely after having, initially perhaps, been too enthusiastically embraced by donor agencies. It may be that FSR&E will eventually be shown to be too expensive, both financially and in terms of human resources, for low income countries. But it is too early to tell. At present, there is a need to make long term commitments to see how and if the FS approach can help ministries of

agriculture deal with the problems they are facing.

One of the most encouraging signs that the FS approach could eventually have a significant impact on national research programs is the attention being given to developing country and institution specific methodologies for FSR&E. Relatively few national programs have accepted FS methodologies developed at the international centers as a package. Rather, these methodologies have served as an outline for initiating FSR&E.

In light of innovations in FS methodology which are undoubtedly taking place elsewhere, while concurrently subsidies for FS programs are likely to start declining, an important task before us is to identify commonalities in our experiences in order to make sure resources used for FS activities are used effectively and efficiently. The halcyon days for FSR&E are over.

In this paper, we discuss FS methodology for harsh environments. We begin by characterizing common features of farming systems in harsh environments and identifying implications for FS program goals, and for FS technology design and evaluation procedures. We believe that FSR&E in harsh environments requires more understanding of system dynamics than in more equable areas where self-sustaining recommendations can be more quickly identified.

We then shift our discussion to a brief overview of the approach to FS work being used by the Agricultural Technology Improvement Project (ATIP) in Botswana. ATIP has a dual mandate:

(a) To develop, test, and disseminate relevant improved technologies for limited resource farmers; and
(b) To improve the capacity of the government of Botswana to develop and disseminate technologies.

A major objective of ATIP has been to identify appropriate procedures for FSR&E in countries such as Botswana, where the environment and a lack of technology already on the shelf prevent substantial improvements in farming system productivity, at least in a short or medium term framework.

CHARACTERISTICS OF FS WORK IN HARSH ENVIRONMENTS

Several features might be taken into account in determining whether a production environment is "harsh". In the Philippines, for example, the Farming Systems Development Project-Eastern Visayas is mandated to develop improved technologies for upland areas where soils are poor and unstable. Farmers can only cultivate lands for a few seasons before returning it to fallow for several years. In the arid and semi-arid zones of West Africa, uncertain rainfall poses a major problem, as the well-known "Sahalian drought" demonstrated.

To generalize, we define "harsh environment" farming systems as ones where farm production and resource productivity are low and unstable and the technical environment prevents substantial and/or reliable improvements in productivity.

In Botswana, we face a combination of low and erratic rainfall coupled with poor soils. In eastern Botswana, where most agricultural production

takes place, the long term rainfall average is between 450 and 500 mm per year, with large inter- and intra-annual variations, and no month when rainfall exceeds potential evapotranspiration. In years of average or better rainfall, yields for sorghum, the staple food grain, are around 200 kgs per ha. During drought years the situation is much worse. Many farmers do not even plant and those that do get little or nothing for their efforts. Meanwhile, cattle, which form the backbone of the rural economy, die faster than they can be sold or are sold at prices much below their levels in normal seasons.

The three years of ATIP's existence have coincided with bad rainfall years for arable agriculture. Thus, ATIP has been faced with a particularly harsh environment as far as technology design and testing work is concerned. The three seasons have brought home to ATIP personnel several observations regarding the nature of farming systems in harsh environments. These observations perhaps pertain to farming systems in less harsh environments but are, we believe, particularly important in harsh environments.

In this section we identify implications of harsh environments for: (a) FS program goals and management; and (b) FS technology design and evaluation procedures, based on our observations in Botswana. Obviously, our observations only represent hypotheses which need to be examined against the experiences of other FS programs operating in harsh environments.

FS PROGRAM GOALS AND MANAGEMENT

Our general observation and hypothesis is that FS programs in harsh environments are, and have to be, broadly focused, encompassing much more than the primary concern of FS work with increasing farm productivity through technological change. The notion of a broader focus can be broken into four components.

1. In many countries where there are harsh environments, there are also areas that are more equable. Consequently, harsh environment systems often are not targeted in order to make substantial contributions to national income or production (Norman, Baker and Siebert, 1984). Rather, employment, equity, and food security goals often are dominant. For example, in Botswana reducing reliance on food grain imports from South Africa and creating employment opportunities through increases in arable crop production are important national goals even though Botswana's comparative advantage is in livestock and mineral production. Thus, FS activities are not necessarily focused only on interventions which will have the greatest impact on farm productivity.

2. FSP usually needs to receive greater emphasis in harsh environments since there generally are support systems problems which limit the possibilities for increasing farm productivity as much or more than an absence of relevant improved technologies. For example, fewer extension workers per household are generally located in harsh environments and their morale is often low. However, development of support systems is difficult since it is unlikely that support system investments will generate sufficient income to pay for themselves. Research is therefore needed on support systems related problems and on the economics of investing in improvements in support systems versus investments in improving agricultural production technologies.

3. The problems of harsh environment zones or countries often go beyond low farm productivity, the focal point of most FS activities. Health and education services, human water supply, transport networks, etc. usually are equally important problems, and are usually exacerbated in such environments. Therefore, it may not be tenable to approach FS work "with a predetermined focus" (Norman and Collinson, 1985), ignoring the larger context of farmer welfare. Further, in terms of FS management, it can be difficult to draw a dividing line between FS activities of interest to a ministry of agriculture and use of the FS approach as a general method for setting and achieving development priorities.

4. There are generally not many technologies already on the shelf to select for alleviating the identified constraints of farmers. Consequently, rather than a concern with quick results, the orientation of FS work in harsh environments will usually need to be modified to one of building toward significant results following a 10 to 15 year investment in FS work. It is generally necessary to accept incremental, evolutionary changes.

When there are not technologies on the shelf, complementary relationships with experiment station based research are critically important to FS work, adding another dimension to FS management. Not only does FSR&E need to influence the research programs of experiment station based scientists, it may be necessary for them to do some technological developmental work on farmers' fields. Thus, FS management will have to be capable of coordinating collaboration between FS teams and experiment station researchers for the purpose of generating technologies, not just verifying or adapting technologies.

FS TECHNOLOGY DESIGN AND EVALUATION PROCEDURES

As a rule, FS work is focused on a few leverage points where the potential for gains in productivity are the greatest. The entire focus and nature of design work is likely to be different for harsh environment systems, entailing greatly increased attention to the nature of system dynamics. In essence, aspects of activities normally associated with diagnosis and testing become part of an ongoing, iterative technology design process. Several specific observations regarding technology design and evaluation follow.

1. Farmers operating in harsh environments buffer themselves as much as possible against disaster. Three buffering strategies hold important implications for FS technology design and evaluation.

(a) Whenever possible, farmers pursue other activities which have higher or at least more certain returns to resources. For example, in Botswana, because of the risky nature of crop agriculture, farmers keep livestock and brew traditional beer, as well as grow crops. As a result the opportunity costs of intensification of crop production can be high relative to the expected returns. In such situations, technology design and evaluation must involve an assessment of likely returns to investments in risky arable agriculture relative to alternative enterprises. Moreover, in harsh environments where farmers are likely to have relatively low levels of income, non-income sources of utility associated with farming may be important and should be taken into account when designing and evaluating new technologies.

(b) The strategies farmers pursue vary according to how the year develops. Sequential decision-making, in which actions are contingent on subjective expected values of alternative actions, are very important. Thus, to be seen as relevant, technology design must focus on developing a series of contingent recommendations for different years.

In order to develop contingent recommendations, there is a need to understand when and in what form existing and proposed technologies succeed. This necessitates detailed monitoring and analysis of the technical determinants of cropping and livestock outcomes over a multi-year horizon. Secondly, researcher managed and implemented (RM-RI) trials, usually considered a design activity, will often need to receive relatively greater emphasis in harsh environments. RM-RI trials can increase the probability of producing tangible results, particularly during drought years. Thirdly, attention of the social scientists needs to be given to research on farmers' subjective probabilities.

(c) Farmers in harsh environments often minimize inputs in the face of production and/or price risk. Moreover, few farmers perceive arable crop production as a way of producing a surplus. Rather, they attempt to meet some of their subsistence requirements from it. Consequently, a mandate to increase arable production and productivity may not be consistent with overall risk management strategies of farmers. It is important to understand risk management in a multi-year horizon in order to design appropriate interventions. In addition, it likely will be necessary to demonstrate benefits since farmers tend to be skeptical after years of failed extension recommendations and accumulated experiences with failed attempts at increasing production.

2. There tends to be little flexibility in the timing of farm operations in harsh environments. Thus, interventions have to address the issue of breaking bottlenecks rather than exploiting flexibility in the system. For example, Batswana farmers facing low and erratic rainfall must plant when they can, rather than adjusting the time of planting to reduce a weeding period labor constraint. Because of limited flexibility, it may be necessary to introduce row planters so weeding can be done using mechanical cultivation. Breaking bottlenecks often calls for much greater system changes, in terms not only of management but also in terms of resources.

When the first step up the technology ladder involves a lumpy expensive input, such as purchase of a row planter or draft power in Botswana, rather than a divisible input such as improved seed, the ability to adopt those improved technologies which are available often is dependent on resources available to the household . Unfortunately, in many harsh environments including Botswana, there are large variations in farmer resources. Thus, FSR&E activities tend to reinforce income and wealth disparities, making income and wealth distribution assessment particularly important for technology design and evaluation. Furthermore, since ability to adopt improved practices is dependent to a great extent on resources available to the household, endogenous stratification criteria are important for defining research domains (RDs). The discipline of targeting research taking into account household assets is needed since it is often difficult to develop relevant technologies for the poorer farmers.

3. It may be necessary to change several aspects of a system in order to have any effect, rather than one or a few leverage points. This is because it may be necessary to exploit interactions among interventions before the expected value and distribution of outcomes is reasonably large. This poses a problem since it is difficult to continue testing multiple technologies in factorial trials until sufficient confidence is placed on entire system changes. Therefore, it may be necessary to test entire systems, modifying of the IRRI cropping systems approach (Zandstra et al., 1981), with many superimposed trials, rather than use the CIMMYT yes-no and levels trial approach (Byerlee and Collinson, 1980; Perrin et al., 1980). This in itself is a problem since adoption of entire packages is inconsistent with most farm management practices.

4. While the so called leverage rule emphasizes the size of gain from an intervention, returns to research resources depend on the size of gain per adopter times the number of adopters. In harsh environments, where all gains are small in absolute terms, non-leverage interventions may need to receive additional attention, at least at the design stage. Gains in non-leverage areas can lead to additional income and attitudinal changes which make changes in leverage areas more possible.

5. Not surprisingly in harsh environments, there often are strong inter-household linkages serving as informal social support systems. Interventions which increase the returns to particular households may have major negative effects on other households in the community. While this can occur in any environment, the degree is generally more severe in harsh environments. There is a need to pay particular attention to ex ante assessment of technologies impacts throughout communities.

6. In harsh environments there generally will be a low return to investments, so no general rules of 50 or 75% returns can be used.

7. In harsh environments fewer clear trial results are obtained since environmental variation often can dominate treatment effects. If a FS team chooses to manage a trial in order to better control environmental and managerial sources of variation, farmers likely will have too little experience with the technologies to provide evaluation. Therefore, the contributions farmers make to technology evaluation often is less, at least during the early stages of designing and screening technologies. This can be a major problem since, as was pointed out above, non-income sources of utility and farmers' subjective probabilities can exert a large influence on farmers' responses.

8. Most analyses used in FSR&E rely on significant differences in means. There is, particularly in harsh environments, a much greater need to understand distributions. For example, when variation is great, misallocation of resources will not be be captured in production function efficiency analysis and substantial mean differences might be missed in ANOVA of trials.

9. Finally, one might hypothesize that the FS approach, itself, may not provide a sufficiently comprehensive framework for designing and evaluating technologies for harsh environments. Harsh environments often are fragile environments. Interventions which are judged beneficial even from a whole

farm perspective may destablize the environment when adopted by a large proportion of farmers. It may be necessary to adopt more of an ecosystem perspective.

DEVELOPMENT OF A FARMER COOPERATOR APPROACH

In presenting our observations on farming systems in harsh environments we hopefully have clarified why we believe FS work must focus on gaining a detailed understanding of system dynamics. In brief, one could say there are no quick fixes and attempts to promote quick fixes have more potential for harm than they do for benefit.

In this section we turn to a summary overview of the approach we have been using in Botswana to design and evaluate improvements in farm productivity. A key feature of the approach to FSR&E developed by ATIP is farmer cooperator studies. In this approach, research is focused on a limited number of representative households in a few villages. Overtime, these households participate in a number of research activities, including resource monitoring, field monitoring, trials, informal visits to discuss and assess innovations, and a series of single-visit surveys directed at particular topics.

We believe the farmer cooperator approach has several advantages for FSR&E in harsh environments. For example, one is better able to address issues relating to intra-household decision-making and inter-household linkages. Trust is built up leading to improved feedback from farmers. Systems dynamics over time can be observed as they impact on particular individuals and households. Moreover, a farmer cooperator approach represents a compromise reflecting the interests and methodological procedures of agronomists, animal scientists, economists, sociologists and anthropologists. As such a farmer cooperator approach may be appropriate for interdisciplinary FSR&E in less harsh environments as well.

In characterizing our approach, we begin with a summary of the procedures used to initiate FS work. Since the initiation of FS activities in the Mahalapye area in September 1982, more than 20 surveys have been designed and administered, including two multiple-visit surveys. Detailed plot monitoring has been carried out on 200 to 300 plots per season and more than 20 trials have been implemented. Most of these activities have been carried out in cooperation with subsets of a group of 52 farming households. We cannot possibly discuss the objectives and justifications for each of these activities. So, in the second part of the section we merely list the diagnostic and trial activities which have been carried out and discuss characteristics of the farmer cooperator approach.

INITIATION OF ON-FARM RESEARCH

Initiation of on-farm research encompassed several activities spread through the 1982-83 season. Before on-farm research could begin, villages were selected and approved, an exploratory survey conducted, a village sample frame created, and farmer cooperators selected. Later in the season, after on-farm research activities were underway, two surveys were administered which in part served to verify that our villages and farmers were representative of farmer circumstances and practices in the Central Agricultural Region (CAR).

Village Selection

The Project Paper proposed that ATIP research coverage would be limited in terms of extension areas and participating farmers. This research approach is based on the view that differences among farmers within a village, in terms of resource endowments and production practices, can often be more important for adoption of technologies than are differences across villages. This was thought to hold in the CAR where there is a similar agro-climatic environment.

In consultation with representatives from the GOB and USAID, it was decided that research activities would be concentrated in two villages, one each in Mahalapye West and Mahalapye East Districts. In September 1982, three trips were made out of Mahalapye to consider extension areas. Three criteria dominated village selection: a village had to have at least 100 households, sandveld and hardveld soil types would be present, and it should be possible to reach the village within one to one and a half hours.

The two selected villages were Shoshong, in Mahalapye West District, and Makwate, in Mahalapye East District. Both villages are large enough for sampling adequate numbers of farmers to participate in research activities and were felt to be representative of farming systems in the CAR. The soils in both extension areas are hardveld types. A sandveld extension area was not included because of extreme logistical problems and because hardveld dominates the arable sections of the CAR. Since Shoshong is a large village, encompassing two extension areas, it was decided to work just in Shoshong East, one of the two extension areas.

Following initial village selection, approval for village research was sought through village meetings scheduled by village headmen in each area. Approvals for working in Shoshong East and Makwate were received at village meetings held in early October 1982.

Exploratory Surveys

A basic tenet of the FS approach is that research priorities should be established in conjunction with farmers. To gain a preliminary understanding of farming practices and the problems and opportunities faced by farmers, fieldwork began with exploratory surveys in Shoshong East and Makwate during October, 1982.

Exploratory surveys in each village were carried out by two interdisciplinary teams. Each team consisted of at least one agronomist and one agricultural economist. Eight to nine person-days were spent in each village. The interviews were informal and unstructured. However, a checklist of information on practices and problems was compiled during the interviews. Debriefing meetings were held each evening to review findings and identify key issues to pursue in subsequent interviews.

The exploratory surveys provided information for deciding on priority research topics and establishing RDs. Six RDs were identified, groups of farmers with similar problems and for whom the same solutions might be relevant. The RDs were based on whether owned, managed or borrowed versus hired or shared draft power (tractor, oxen or donkey) was used by farmers. The draft arrangement used by a household was hypothesized to be a critical

factor affecting its ability to implement timely planting operations. Timely planting was hypothesized to be a key determinant of plant population which is in turn a key determinant of yields.

Sample Frame Census

Once having tentatively set RDs, it was important to verify that the RDs could serve as a viable approach for stratifying farmers in Shoshong East and Makwate. In addition, it was necessary to have a sample frame for future sample selection. Therefore, to provide an empirical idea of the characteristics of farming families in the two extension areas, a 16 question census was administered to the households in Shoshong East and Makwate during the last week of October and early November, 1984. The census included key variables required for stratifying households into RDs. Following a brief training session, nine enumerators seconded from the Central Statistics Office covered both areas in two work-days. Eight additional person-days were spent resurveying households which had been incompletely enumerated the first time through.

Data from the Sample Frame Census (SFC) were initially hand tabulated and findings were used to select ATIP farmer cooperators. Later, after the data were put on the microcomputer, data listings were used in selecting samples for two diagnostic surveys.

Some of the results of the SFC are summarized in Table 1. In Shoshong East, there were 321 households. Makwate is a smaller village with just 161 households. A substantial proportion of the households in both villages were headed by females. The vast majority of households in both areas were involved in crop production. Almost all households engaging in cropping activities managed lands but several households shared land allocation with relatives.

The primary forms of traction in Shoshong East were cattle traction and tractors. While cattle traction was the dominant form of traction at the beginning of the 1982 season, nearly a third of Shoshong East households primarily used a tractor traction. (There has been a shift toward tractors since the 1982-83 season due to drought.) Makwate was and is a donkey village. Until the beginning of the 1985 season, very little tractor traction was used. Taking both villages together, about half the households primarily used cattle and the others were approximately evenly divided between donkeys and tractor.

Many recommended practices taking hold in other areas of Botswana have not made much progress in the Mahalapye area. This was reflected in the almost exclusive use of broadcast planting in both areas. The traditional nature of crop production in Shoshong East was reflected in the small proportion of households that had fenced their lands. In Makwate, a majority of households had wire fencing.

While most households in both areas engaged in crop production, arable agriculture was but one activity for essentially all the households and a minor one in many respects for most households. Livestock were more important than crop production for most of the households, particularly in Shoshong East. More households owned cattle in Shoshong East than in Makwate and the

size of cattle herds was larger. In addition to livestock activities, half the households said they derived income from village activities such as selling beer or had income from outside the village, primarily remittances from relatives working outside the village. Most of the other households said they they had income from both inside and outside the village. Only a small proportion of households said they had no other source of income than crop production. (The Makwate figure in Table 1 probably is accurate for both villages since the Shoshong East estimate did not hold up under subsequent surveys and rechecking.)

Farmer Selection

The selection of farmer cooperators is perhaps the most crucial step in a farmer cooperator approach. When selecting a relatively small number of farmers to serve as cooperators, they should be representative of the population with respect to the primary research agenda. In order to make sure households representing each RD were included, we stratified our population before selecting cooperators within in strata. The relative number of households selected in each strata was determined by the relative number of households in each strata in the population as a whole so results would not have to be weighted when presenting findings for each or both villages. It was decided to select independent samples for the on-farm trials and the resource monitoring survey, so that results of the resource survey would not be affected by adjustments in resource use patterns stemming from participation in RM trials.

To begin the selection process, results from the SFC were tabulated and the proportions of the population falling in each research domain calculated for each village. It was decided that ATIP would be able to work with approximately 25 households in the on-farm trials program and 25 to 30 in the Multiple-Visit Resource Use (MVRU) Survey. The size of the MVRU sample was based on an assessment that each of three enumerators could interview five households a day, twice a week, with one day for re-contacts.

To select farmers, the following steps were taken. First, the total number of farmers to be included for each sample was multiplied by the proportional representation of that domain in the population. For example, if 10% were to be donkey hirers, then we were to select 3 donkey hiring households (0.1 x 30). Second, the listings of households from the SFC were divided into the RDs. Third, households in each RD were randomly selected from the stratified listings. Fourth, each household was interviewed from one to three times to confirm that information from the SFC was correct, farmers understood the nature of the program, and farmers were willing to participate on a long term basis. If farmers were not interested in participating, that household was rejected and the next household on the list contacted. Sometimes several visits were made in order to reduce the chance of rejection because farmers were merely intimidated.

Some adjustments were made in the course of selecting each sample. For the trial cooperators, cell proportions were adjusted slightly to make sure there was minimal representation of all domains (except tractor owners), to have replications. Second, the trials program required that farmers had fenced fields, and this may have led to a slight upward bias in the relative wealth of farmers in the "trials" sample.

For the MVRU sample, it was decided to subdivide RDs into poor vs. rich (based on cattle ownership) and male vs. female headed households. Again, population proportions were used to determine how many male vs. female households and rich vs. poor were to be included in each cell. Second, households with only one or two members were not included, since we wanted a perspective of resource allocation in households, not just for individuals. Third, a retrospective survey was administered at the time households were interviewed. A couple of farmers were rejected because they did not think it important to recall resource use information. Fourth, it was necessary to cluster the sample in Shoshong East since enumerators were to bicycle to the fields for interviews (more than 10 kms. from the village). Therefore, households having extremely distant fields (more than 25 kms.) were not considered. Once most farmers had been selected, clusters were filled out clusters by making contacts in the lands area themselves. We drove through the targeted areas, interviewed farmers at randomly encountered compounds, and included the household if it fit our quotas based on traction, draft access, sex of household head, and cattle ownership. It was not necessary to cluster in Makwate, since most fields are quite near the village.

Nearly two months were spent on farmer selection (and the retrospective survey). By the middle of December 1982, 52 farmers cooperators had been selected, and both trial and survey activities initiated. The representation in terms of sex of household head, type of traction and draft access was quite close. Cattle ownership representation appeared to be off somewhat but, in the course of our farmer selection interviews, we found this was due to unreliable results of the SFC with respect of cattle ownership rather than a feature of our cooperators sample. Specifically, many farmers with few cattle claimed they had no cattle in the SFC.

Verification Surveys

Since research was centered on a small number of cooperators in two villages, it was important to make sure those cooperators and villages were typical of the wider population. Therefore, two surveys which had as one primary objective verifying that our primary research villages and farmer cooperators were representative were designed and administered during the first year. The two verification surveys were the Crop Management Survey and the Agricultural Demonstrator Survey.

The primary objective of the Crop Management Survey, administered in May and June 1983, was to provide an overview of farming practices and farmers' problems and preferences in Shoshong East and Makwate. Sample verification was a secondary objective. For this reason, the topics covered in the survey extended beyond those necessary for sample verification. The survey instrument was a single-visit questionnaire with seven sections: (a) household profile, (b) plowing situation, (c) crop enterprises, (d) crop husbandry, (e) resource constraints, (f) farming hazards, and (g) food supplies and preferences.

The questionnaire was administered to MVRU and Trial farmers in both extension areas. In addition, 66 randomly selected farming households were interviewed: 38 in Shoshong East and 28 in Makwate. The sample frame for selecting farmers was the SFC. The randomly selected households made it

possible to derive descriptive statistics for each extension area and to test the hypothesis that structural characteristics of the MVRU and Trial households were not significantly different from other households in Shoshong East and Makwate.

Summary results comparing characteristics of ATIP cooperators with randomly selected households in Shoshong East and Makwate are presented in Table 2. As can be seen, there were very few characteristics which differed between ATIP cooperators and the random sample. Although not significantly different, tractor use and the number of cattle owned were greater among ATIP cooperators. This largely reflects the fact that the proportion of farmers coming from Shoshong East, a livestock oriented village, was larger in the ATIP sample. While differences in cattle ownership were not statistically significant, one could reasonably infer from the combination of differences in cattle owned and equipment owned that ATIP farmers probably had slightly greater assets than did the random sample farmers. Any differences were not reflected in traction use, household demographics, land resources, or consumption.

The primary purpose of the Agricultural Demonstrator (AD) Survey was to assess the extent to which problems identified in Shoshong East and Makwate were typical of problems throughout the CAR. A survey of ADs was thought to be a more cost and time effective means of gaining a preliminary farming systems profile than would have been a survey of a randomly selected sample of farmers from throughout the CAR. The survey had two additional objectives: (a) to gather information on activities of ADs and constraints on their effectiveness; and (b) to provide an opportunity for interaction between ATIP researchers and ADs of the CAR.

In March 1983, a questionnaire was distributed to ADs in the CAR at their monthly management meetings. There were five sections to the questionnaire: (a) AD situation and activities, (b) farming systems profile, (c) institutional issues, (d) AD perceptions and attitudes, and (e) rankings of problems and objectives. ADs were requested to mail-in the completed questionnaire. Eventually, questionnaires were received from 52 of 54 ADs in the CAR. After his or her questionnaire was returned, each AD was interviewed in order to eliminate as many mistakes as was possible.

The main results of the AD survey with reference to the verification objective were: (a) there were relatively few differences between extension areas in terms of crops grown and crop management practices; and (b) variability among enumeration areas within districts was much greater than the differences among districts. The survey results supported the view that it should be possible to carry out farm management research and on-field testing of improved technologies, at least in the RM-RI and RM-FI stages, in just one or two districts. The survey also showed that villages clearly differ in key aspects, such as dominant type of traction used. If FS work was to be concentrated in only a few villages, it would be necessary that those villages capture the configuration of key village characteristics. Fortunately, the survey showed that Shoshong East and Makwate together well represented the most common types villages in the Central Region.

SUBSEQUENT DIAGNOSTIC AND TECHNOLOGY GENERATION ACTIVITIES

By the beginning of 1983, the structure of our farmer cooperator approach was established. The verification surveys were administered and at least partially analyzed by the middle of 1983. At that point, after our first season, we decided that the harsh environment in Botswana required a FS approach that included ongoing system diagnosis, involving monitoring of income and resource flows and technical plot monitoring, and a broadly focused trials program.

Once having accepted the need for information on income flows, resource use patterns, and the technical determinants of cropping outcomes, the question became one of developing a methodology which is consistent with the pragmatic aims and budgets of FS work. In developing an appropriate FS approach, we first had to decide on principals governing sample size and composition. Specifically, we had to decide: (a) whether to shift from a small sample approach to a larger sample of farmers; and (b) whether to continue with the same cooperators from year one or to select a new set of cooperators.

The decision on sample size was relatively easy. We decided that a small sample, once we knew it was representative, was preferable to a large sample for several reasons:

(a) Measurement errors can be reduced and unique features of households affecting observed patterns of resource flows can be easily identified.
(b) Diagnostic surveys could serve as a means of verifying and further analyzing observations based on personal contact, rather than serving as a substitute for personal contact.
(c) Enumerators and farmers would soon became familiar with the questions, reducing researcher time necessary for checking data.
(d) If properly selected, small samples can represent the range of farmer circumstances.
(e) Responses of new farmers to technologies can always be assessed in verification trials after initial testing activities have taken place.

Several features of farming systems in Botswana also mitigated against shifting to a new group of farmers in year two. Some of these have been discussed in general terms above as observations about harsh environment farming systems. Four considerations were particularly important:

1. Agricultural production is just one source of household income. Wage employment, remittances and even traditional beer brewing can be as important sources of income. Information on some of these income sources is sensitive and requires repeated visits by individuals who know and are known to each household. The quality of information is improved as trust is established.

2. Households are managed by multiple, interacting individuals. Even when there is a male head of household, women and children have their own activities and make their own decisions. An understanding is needed of intra-household dynamics over time in order to appropriately design and evaluate technologies.

3. Most households have members spread over several locations. In addition to field and village compounds, one must take into account household members living at the cattle post or working at jobs outside the village area. Because of the complex and dynamic structure of households, we felt it was

necessary to identify and assess household composition and circumstances on a case by case basis.

4. Rainfall in the 1982-83 season made it impossible for all but a few farmers to produce crops or to maintain their animals in reasonable condition. Still, certain farmers were notably more successful than others. It emerged as a top priority to be able to identify the relative productivity of farmers with different household circumstances in different years and the adjustments different farmers make to changes in environmental circumstances.

Consequently we decided to continue with the same farmers in the second year of the program, and again during the third year. A list of the FS activities of the Mahalapye team through the 1984-85 season is presented in Table 3. As can be seen, farmer cooperators were the focal point of nearly all activities.

Between 1983 and 1985, several features of our farmer cooperator approach became more clearly defined. In terms of initiating FS activities, the key features of the approach, discussed above, are the village focus, reliance on a small sample of farmers for repeated activities, and the procedures used to select farmers and verify the representativeness of our samples. As our program evolved, seven additional characteristics of a farmer cooperator approach emerged with respect to diagnostic and technology generation activities:

1. We increasingly relied on purposively selected subsets of our cooperators and particular individuals within households for technology design and testing activities. For example, if an intervention required a decision about what seed to use, we approached the women in households who were known to be responsible for that decision. Similarly, trials requiring multiple tillage operations were implemented by individuals known to be active farmers and interested in intensifying their arable crop production enterprise.

2. The independent samples of cooperators were integrated beginning the second year, to the extent that all farmers were given the opportunity to participate in trials. Cooperators appreciate seeing trial plots in their fields, even though they are only "tests, not demonstrations." By integrating the samples, we had more representatives for different sets of farmer circumstances.

3. We phased down our contacts, particularly with the MVRU sample, in order to reduce demands on the cooperators. For example, in year two the number of questions asked was greatly reduced. In year three, a purposive subset of only 13 household participated in the MVRU survey, and the survey was cut back to concentrate only on household income activities. Also, after the second season, several Trials cooperators with a marginal interest in arable production were no longer active in the trials program but continued to be interviewed in various subject surveys.

4. One of the key features of the approach was the periodic collection of some key data. In each season we collected data on plowing situations, including types of traction, draft access, and timing and amount of plowing. For some farmers we have multiple year profiles of household demographics, farm fixed capital and livestock inventories. Synthesizing information about

changes in profiles over time for different categories of farmers provided an important perspective on farming systems in the Mahalapye area.

5. Reliance on cooperators allowed us to minimize the use of enumerators. At the beginning, two village staff were responsible for the MVRU survey and two others were responsible for trials and plot monitoring. By the third year, only two enumerators were required for both the plot monitoring and the MVRU survey since the sample sizes for both activities were greatly reduced. All other survey activities and the initiation and management of trials were carried out by a small group of researchers, a maximum of five, based at Mahalapye.

6. An important factor relating to the credibility of the approach was the increasing use of noncooperators under particular conditions. For example, during the recently completed season we conducted a study on intra-household decision-making and farmers' perceptions of practices ATIP is engaged in testing. We felt our cooperators might have become be atypical with respect to views on arable production technologies, so we relied instead on the set of randomly selected farmers which participated in the 1983 Crop Management Survey. This gave us a nice compromise. We were able to evaluate changes in circumstances and attitudes overtime but did not have to worry about sample bias. Another circumstance where we turned to noncooperators was for implementation of FM-FI trials. Some trials require relatively little researcher involvement and some involve assessments of farmers' abilities to implement a technology. In either situation, we found it useful to use noncooperators to increase the likelihood that our managerial assessments were not distorted by any behavioral modifications of our cooperators.

7. A minor but important aspect of the approach was provision of some services to the cooperators. This was limited to provisions of seed for most trials, occasional loans of equipment when it is needed, inexpensive watches to help farmers report on labor use, information on agricultural programs, and participation in field days. Farmer cooperators should be able to realize some benefits for all the help they give FS programs.

CONCLUSIONS

In this paper we tried to identify unique features of farming systems in harsh environments and implications for FS program goals and appropriate FS technology design and evaluation procedures, based on our experiences in Botswana. We believe many of our observations are relevant for FS programs operating elsewhere in harsh environments and perhaps even for programs in more equable environments. We then turned to a description of the development of a farmer cooperator approach by the Mahalapye team of the ATIP project, as an example of an approach we think is particularly suitable for FS programs operating in harsh environments.

A few points should be kept in mind when evaluating the value and relevance of our approach for other FS programs. First, the approach described is based on experiences of the Mahalapye field team. There are unique circumstances in the CAR which are conducive to a farmer cooperator approach: (a) the combination of vast distances; (b) a relatively homogeneous institutional and technical environment; and (c) large variation in farm productivity associated with assets and draft access.

Second, ATIP is located in the Department of Agricultural Research and the Mahalapye team has a mandate to develop improved arable production technologies. Thus, activities related to livestock, social institutions and extension were included on our agenda because of our observations, presented above, that FS technology design and evaluation activities must be broadly focused. Even more time might have been spent on these activities if they had been a part of the mandate.

Third, we do recognize that diagnostic and design research activities have opportunity costs with respect to testing and dissemination. To the extent promising interventions can be identified, a farming system is less harsh, by our definition, and FS work as conventionally practiced becomes an effective alternative.

Fourth, team members were forced early on to take a long run perspective, rather than focus on short run changes in farming systems. Shifting away from a preoccupation with the short run had perhaps the most profound effect on the approach we have used for FS work but this may not be an option for other FS programs.

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Table 1: HOUSEHOLD CHARACTERISTICS IN SHOSHONG EAST AND MAKWATE, OCTOBER 1982

VARIABLE	SHOSHONG EAST	MAKWATE	ALL
Households	321	161	482
Average Household Size	6.4	7.4	6.7
Percent: Female Headed	36	41	38
Engaged in Crop Production	80	77	79
Managing Lands	71	72	71
Primary Traction (Percent Using):			
Cattle	64	17	48
Donkeys	3	81	29
Tractors	33	2	23
Fencing (Percent With):			
Wire Fencing	16	62	31
Bush or No Fencing	84	38	69
Percent Broadcast Planting	97	97	97
Percent Owning Cattle	60	47	56
Average Cattle Herd Size:			
Cattle Owners	36	19	30
All Households	25	12	21
Access to Income (Percent of Households With Income From)			
Inside Village Activities	25	41	30
Outside the Village	20	21	20
Inside and Outside Village	39	37	38
Neither	16	1	12

Source: 1982 Sample Frame Census

TABLE 2: ATIP COOPERATORS COMPARED TO RANDOM SAMPLE

VARIABLE	ATIP	RANDOM
DEMOGRAPHIC:		
Percent Male Headed	61	59
Year Head Born	1930	1929
Members > 16 Years	4.7	4.6
Members < 15 Years	4.7	4.2
Active in Cropping	2.8	3.1
Have Wage Employment	1.2	1.4
NUMBER OF INCOME SOURCES	2.9	3.1
CATTLE OWNED	41	25
NUMBER OF IMPLEMENTS	1.4	0.9/a
LAND:		
Years Field Cultivated	22	21
Seasons in 10 Use All Land	4.5	5.0
PRIMARY TRACTION:		
Donkeys	34/b	41/b
Cattle	36	38
Tractors	30	21
PRIMARY ACCESS TO DRAFT:		
Own	56/b	52/b
Borrow, Manage, Mafisa	6	11
Hire	29	29
Cooperative Arrangement	8	9
AMOUNTS OF PLOWING:		
Days Plowed '82-83	5.7	4.7
Days Plowed Good Season	11.3	8.8
Acres Plowed '82-83	9.1	8.6
Acres Plowed Good Season	16.0	15.5
CONSUMPTION:		
Bags Grain Per Month	1.3	1.2
Days Drink Milk Per Month/c	14	13
Days Eat Gathered Food/c	19	23
Consume Goat Meat Per Month	3.0	3.9
Consume Beef Per Month	5.1	4.5

Source: 1983 Crop Management Survey

a. Significant difference at .95 confidence level.

b. Percent of households.

c. Frequency refers only to the cropping period for these are seasonally consumed.

Table 3: Follow-On Diagnostic and Trials Activities, 1982-1985.

ACTIVITY	SAMPLE	FOCUS
1982-83 SEASON		
WHOLE FARM STUDIES:		
(a) Multiple-Visit Resource Use Survey (MVRU)	27 Households*	Cash Flows, Labor Use, Income & Household Maintenance Activities, Market & Non-Market Exchanges
(b) Technical Plot Plot Monitoring	192 Plots on 23 Fields*	Farmer Inputs, Soil & Climatic Conditions, & Crop Response by Plot
ON-FARM TRIALS:		
(a) Evaluation of Planting Methods	15 Sites*	Sebele Plow-Planter & Row Planter; Third, Furrow Hand, Harrow
(b) Tillage System Investigation	Multiple Strips in Two Fields*	Double Plowing, Early & at Planting
(c) Sorghum Intercropping	RM-RI Trial on one Field	Establishing of Late Season Undersowings
SUBJECT SURVEYS:		
(a) Draft Arrangements	About 70 Households*	Plowing Situation; Interhousehold Arrangements
(b) Agricultural Demonstrator	54 ADs	Activities of ADs; Regional Profile of Farming Systems
(c) Crop Management	116 Households	Crop Enterprises; Crop Husbandry; Resource Constraints; Hazards; Food Preferences
(d) Within Field Variability	200 Field Sites*	Soil and Topographical Characteristics & Associated Crop Growth
(e) Weed Survey	50 Farmers*	Weeding Practices and Problems
1983-84 Season		
WHOLE FARM STUDIES:		
(a) MVRU	26 Households*	(See Above)
(b) Household Inventory	26 Households*	Household Census; Livestock Inventories; Farm Fixed Capital
(c) Plot Monitoring	47 Farms*	(See Above)
ON-FARM TRIALS:		
(a) Effects of Early Tillage	2 Reps on Each of Two Farms*	10 & 20 cm Early Plow, Early Harrow & No Early Tillage
(b) Effectiveness of Sole Plowing	9 Reps*	Modified Early Plowing & Planting Method Comparison
(c) Draft Team Management	3 Donkey Teams 2 Oxen Teams*	Energy Supplements on Plowing Days
(d) Evaluation of Benefits	2 Reps Plowed on 13 Plots 5 Plots Harvest*	Relationship Between Early Plowing & Crops; Response to Fertilizer

Table 3 continued.

(e) Cowpea and Mixed Cropping Comparison	16 Farmers*	Blackeye, ER-7, Tswana; Sorghum Mixed wtih Populations of Tswana
(f) Bird Scaring	4 Sites*	Installation of Polyethylene Hum Line
(g) Seed Treatment	12 Farmers*	Captan and Malathion Treatment of Local Seed Lots
(h) Sebele Plow-Planter	3 Farmers in an FM-FI Approach*	Animal Drawn 2 Furrow Unit; Tractor Drawn Unit
SUB-STATION TRIALS:		
(a) Local Sorghum Germplasm Evaluation	69 Seed Lots	Locally Selected Sorghum Populations
(b) Dual Purpose Cowpeas	32 Lines	Variations in Lines of Tswana Cowpeas
SUBJECT SURVEYS:		
(a) Cropping Plans	45 Households*	Planned Enterprises & Husbandry Practices; Seed Availability
(b) Post-Tillage Weeds	59 Plot Situations*	Weed Development on Different Fields
(c) Soil/Root Profiles	15 Fields*	Root Penetration by Soil Strata; Soil Composition Analysis
(d) Institutions, Services & Infrastructure	Shoshong and Makwate Villages	Village Markets & Prices; Government Services; Local Institutional Structure
(e) Cowpea Baseline	51 Households*	Cowpea Husbandry; Product Utilisation; Consumption Patterns
1984-85 SEASON		
WHOLE FARM STUDIES:		
(a) MVRU Households	13 Households*	Successful and Commercial Beer Brewing
(b) Activity Survey	50 Households*	Qualitative Profile of Labor Use
(c) Inventory Survey	50 Households*	(See Above)
(d) Plot Monitoring	13 Farms*	(See Above)
ON-FARM TRIALS:		
(a) Commercial Steps in Technology	5 Sites*	Assessment of Technical Package for Farmers Willing to Substantially Increase Arable Production Inputs
(b) Ridge Plowing	1 Site*	Technical Evaluation of the Ridge Plow
(c) Draft Management	1 Village*	Farmer Assessment of Improved Draft Management Scheme
(d) Intensive Production Plots	12 Farms*	Intensified Inputs Sometimes with Waste Water
(e) Undersowing	13 Farms*	To Incorporate Different Planting Dates of Compatible Crop Components on a Single Plot
(f) Tillage Planting	8 Farms*	Test 2 Tillage/Planting Schemes

Table 3 continued.

(g) Alternative Planting	4 Farms*	Technically Evaluate Sebele Plow Planter & Hand Planting
(h) Crop Seeding Comparisons	17 Farms*	Compare Cropping Options to Seeding Under Traditional System
(i) Cowpea	8 Farms	Look at Cowpea Variety/Tillage Interactions
SPECIAL STUDIES:		
(a) Trader Baseline Survey	163 Traders	Understand Market Structure & Assess Marketing Structure in Central Ag. Region
(b) Farmer Decision Studies	55 Households*	Understand Inter- & Intra-Household Patterns of Decision Making -- 5 Surveys

* Included cooperator farmers.

INCLUSION OF NEW FACTORS IN FSR/E

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REGENERATIVE AGRICULTURE: IMPERATIVES FOR TOMORROW'S AGRICULTURE

Charles Francis, John Haberern, William Liebhart, Tom Barker

Introduction: Constraints to Development

The agricultural development community -- researchers, administrators, planners, politicians -- is emerging from the pleasant euphoria of the past two decades. Inspired by the success of the green revolution with a few crops in some of the most favored regions of the developing world, we encouraged ourselves with the hope that this same technology would have the potential to bring an adequate and stable level of food production to people everywhere. This technical success story brought new varieties of rice and wheat, high inputs of fertilizer and pesticides, and improved management practices together to transform the production capabilities of some regions and make a substantial impact on their food supply. Where these practices proved profitable to the farmer, results have been spectacular in some areas of India, Pakistan, Philippines, Mexico, Colombia, and elsewhere.

Successful application of this technology has provided food to meet some demands of growing urban populations, and can continue to be viable in favored areas as long as inputs are available and the practices are profitable. Yet this intensive technology has not reached the majority of the world's farmers, many of whom work in a resource limited environment on lands which are less easily transformed to high levels of productivity. Creative solutions are needed to design alternative cropping systems and improvements in existing systems for low input farmers. To meet the variety of challenges which faces farmers in the developing world, a multi-faceted strategy is needed which includes a realistic assessment of resource base and farmers' objectives.

This review presents an approach which builds on the existing farming systems and traditional wisdom in agriculture to develop new combinations of cropping practices which can meet production and income needs of the farm family while sustaining and even improving the environment. This approach can be called "regenerative agriculture". Although the discussion and examples focus on developing countries, there are many exciting applications of these principles in developed agriculture as well.

Global Strategy for Regenerative Agriculture

There are a number of components which could be considered essential to a strategy which is appropriate to the development of a regenerative agriculture. These include global decisions such as the concentration on food, feed, and fiber crops for local and national consumption as compared to export crops which leave the region and country. Also critical are specific production practices such as rotations of crops to enhance fertility and integrated pest management to reduce costs of purchased chemical inputs and their undesirable side effects. The emphases and practices which are described all lead to more self-reliant production systems which enhance the income, nutrition and health of the farm family while improving the biological production environment. The topics and practices included here are not

exhaustive, nor do they represent the entire range of possibilities which creative farmers and researchers can devise. They do help to focus on the concept and the implementation of practices which can lead to a regenerative agriculture.

Maximize Use of Farm Level Sources of Fertility

High technology agriculture relies heavily on sources of plant nutrients from off the farm. This reliance on external resources can be shifted to a greater use of the potentials which are internal to the farm. Nitrogen fixation is one of the primary mechanisms which can be encouraged through selection of cropping sequences and leguminous plant components which fix nitrogen from the atmosphere. Rotations of legumes with cereals, or intercropping schemes which include these two types of crops, can lead to an enhanced total level of nitrogen fixation and thus greater use of atmospheric nitrogen, one of the most prevalent resources internal to the farm. Although more research is needed to better understand matching Rhizobia with host plants, promote better fixation under stress conditions, and stimulate higher levels of fixation in complex cropping systems, there are many known potentials which can be used in designing improved cropping systems.

Both annual grain legumes and cover crops provide fixed nitrogen which can be available for subsequent crops in a sequence. Examples are the maize/bean intercrop common in much of the Americas, the sorghum/pigeonpea intercrop or relay crop in sub-Sahelian Africa, and the rice/mungbean (catch crop) multiple crop sequence in Southeast Asia. A maize-soybean annual rotation in the temperate regions of the U.S.A. or Argentina provides another valuable application of this principle. Intercrops of annual crops with perennial species planted specifically for nitrogen production, such as alley cropping maize or cassava with Leucaena or Gliricidia provide all or most of the nitrogen from internal resources; the woody leguminous species also have potential for firewood, animal fodder, and green manure. These systems, and other more complex approaches through agroforestry, are just beginning to receive serious attention from the research community.

Mixtures of crop species or rotations of plant types which have different rooting habits can also contribute to the preservation of nutrients within the soil volume used by plants. Some deep rooted species are capable of bringing up nutrients from lower strata in the profile, and making these plant growth factors available for shallow rooted species. The concept of "phosphorus pumping" is an intriguing potential of this type of system. Plant species interactions are common in natural ecosystems, and a better understanding of what happens in natural plant communities can help in the design of more sustainable cropping systems. When a greater proportion of the nutrients in a system are tied up in living plant tissue or decaying crop residue (organic matter), these nutrients are not easily leached downward through the profile. In contrast, soluble chemical fertilizers are easily lost from the system when rainfall or irrigation pushes nutrients down and away from the root zone and into the groundwater. Problems of groundwater contamination with nitrates are becoming increasingly acute in some areas where low cost nitrogen has encouraged application of excessive levels to annual crops.

Another potential of legumes to contribute nitrogen to an intensive

pattern of annual cash crops is through overseeding the legumes into a growing cereal. Maize can be overseeded with vetch or red clover at the last cultivation or when the leaves begin to senesce. If adequate moisture is available, these legumes can grow through the fall and again in the spring to produce significant amounts of nitrogen for the succeeding cereal crop. These potentials have reached more than 100 kg ha^{-1} in regions of the Eastern U.S.A., and a similar system can be used with soybeans. One additional benefit of the growing legume and its presence in the dormant state through the winter is the prevention or drastic reduction of erosion of topsoil. This is another serious drain on soil nutrition, and erosion control is one of the most direct ways to increase soil fertility through internal resources on the farm. Reduced tillage helps keep the soil and nutrients in place in the field.

Another source of crop nutrition on farms where animals form a part of the total farming system is manure. Most small and medium farms include some animal species, and manure as a source of nutrients often is overlooked as a significant resource. Where animal manure is burned in cooking fires, an alternative source of fuel is needed; this could be branches from woody legumes, biogas from inexpensive digester units, or possibly power generated by wind, water, or solar energy. Manure is an excellent resource which needs to be carefully managed and used to best advantage for crop growth. When there are forages or non-marketable grain products available on the farm, it is logical to feed these through animals to produce both manure for fertilizer and meat as another source of food and income for the family. These are among the resources which are available on most farms, large and small, which could be managed and exploited more efficiently. They are all internal to the farm, and require no costly or complicated technology which would have to be imported. They require an understanding of the natural environment and more refined management skills. These are examples of a regenerative approach to soil fertility.

Seek Creative Weed, Insect, and Disease Control Methods

A creative set of alternatives for pest control has emerged under the general approach called "integrated pest management". This concept includes a careful study of the life cycles of prevalent pests, an evaluation of the levels of damage which would cause economic loss to the farmer, and a consideration of a range of alternatives in control, or management of pests. For example, low levels of weed infestation may not cause crop yield reduction, while the weeds provide some additional cover on the land and a source of green manure. When insecticides are not sprayed on crops to prevent infestation or to control minimal populations of damaging insects, the natural populations of predators and parasites may provide adequate protection. When crops are rotated on a given land area some plant diseases will not be a problem, compared to the same area planted in monoculture. The interactions among crops, weeds, pathogens, and insects and the management strategies which can be used to control undesirable species in the field are becoming better understood, and provide an important potential for the farmer with limited resources.

Crop rotation is a useful and low cost method of controlling many weed species. When the weather or crop cultural conditions vary widely within a period of rotation, such as the wet/dry seasons or upland/lowland seasons in the tropics or summer/winter cycles in temperate zones, a sequence of crops can be established which is counter-cyclical to the patterns of weed growth and

reproduction. In other words, weeds which would be favored in a continuous maize or rice culture could be more easily controlled when these crops are alternated. The rotation of annual crops with alfalfa or other hay crop combinations can provide a high level of control in temperate regions. This potential is available to the farmer with limited resources, and is an example of substituting management skills and a cropping sequence for expensive herbicides. Crop rotation also is known to control such insect pests as maize rootworm and problems such as nematodes.

Intercropping has been shown to reduce insect populations in component species in most of the systems where careful observations have been made (Altieri and Liebman, 1986). Fall armyworm in maize and leafhopper beetle populations in beans were both reduced in a maize/bean intercrop, compared to the respective monocultures in Colombia (Altieri et al., 1978). The additional crop leaf area in an intercrop such as the maize/bean also provides more competition to germination, growth, and reproduction of weed species, thus adding a measure of cultural control to the cropping system. These examples all underscore the potentials of intensive management and the use of information about crops and their associated pests to design alternative cropping systems which depend more on internal potentials and resources than on outside purchased inputs.

Improve Genetic Potentials of Varieties and Hybrids

New rice and wheat varieties which are shortstemmed, nitrogen responsive, insensitive to photoperiod, and highly productive have provided farmers with a new genetic crop potential to exploit the resources in a non-limiting production environment. Maize and sorghum hybrids have brought this same potential to farmers with mechanized crop culture and access to fertilizer and pesticide inputs. As with other components of the green revolution technology developed for monoculture, these potentials have not been exploited by the majority of limited resource farmers in the developing world. One of the greatest challenges facing the plant breeder is the efficient and rapid development of varieties and hybrids which are adapted to a wider range of soil and cropping system conditions.

Many of our soils have been seriously depleted by years of extractive and intensive cultivation, and the farmers who manage these lands do not have access to inputs which can quickly correct the soil problem. Rainfall is limiting in much of the semi-arid tropics, and little potential exists for irrigation. Existing varieties used by farmers may survive under these difficult conditions, but they bring no new genetic diversity nor yield potential into the system. Most varieties and hybrids developed on experiment stations under optimum conditions will be marginally successful at best under these stress conditions, and so far many varieties have not been widely tested in less than favorable growing environments. The challenge is to screen germplasm, recombine the most promising sources for these marginal conditions, and test new genetic combinations under cropping system and agronomic conditions which are likely to prevail on the farm when the new varieties are ready for release. Genetic variation exists for efficiency of nutrient and water use, and this capacity needs to be put together with grain types which are acceptable to the farm family and consumer in each region.

In addition to adaptation to a range of stress conditions in low input agriculture, there may be untapped genetic potential for enhanced potential productivity in complex cropping systems, including intercropping and relay systems. Research results from genotype by cropping system studies have shown that specific adaptation to intercropping exists for some species and not for others. In general, intercropped species which mature at substantially different times, have different patterns of resource use, and have minimal time of interaction in the field have the lowest degree of interaction between genotype and cropping system, e.g. genotypes tend to rank and perform in a similar relative order across a range of systems. Two or more species which are in the field together and share the growing environment for an extended period of time, which compete for light, nutrients and moisture, and which have similar patterns of growth often show a strong interaction of genotype with system, e.g. genotypes show an ability to produce well in specific cropping systems. The potentials for developing crop varieties and hybrids which are specifically adapted to intensive intercropping systems have yet to be explored, although the interest in this area of plant breeding has increased markedly in the past decade.

Achieve a High Degree of Self-Reliance

Through use of resources internal to the farm to provide all or a majority of nutrient needs for the crop, and through application of the principles of cultural control and integrated pest management, a high degree of self-reliance in production inputs can be achieved by the farmer with limited resources (Francis and Harwood, 1985). The discussion of soil fertility needs and the resources which could provide for plant growth stressed the use of nitrogen fixed by legumes and phosphorus and other elements cycled up from lower soil strata. Increasing total dry matter production and the retention of as much organic matter as possible as crop residues and manure applied to the land helps to tie up much of the nutrient supply in organic form; this strongly reduces potential leaching through the profile, as compared to the fate of applied soluble chemical fertilizers. An emphasis on internal resources helps the farmer achieve some degree of self-reliance in production inputs, and makes the system less susceptible to changes in market price or availability of purchased inputs.

Use of rotations, genetic resistance in crop varieties, and intensive systems such as intercropping can help control weeds, insects, and plant pathogens. This integrated approach to pest management can reduce the need for purchased chemical pesticides, and make the farmer potentially more self-reliant. Again, a reliance on locally available resources and a management strategy which minimizes purchased inputs helps to reduce dependence on distant and insecure supplies.

A diversity of crops grown in an effective market region, or that area which trades around one market at a one-week interval also promotes self-reliance in the market region. Such diversity in crops for food and fiber can reduce the need for high investments in transportation and infrastructure which may not function well in some regions and some countries. When farmers are self-reliant in basic food crops in a region, growing most of what is needed and trading for most of the rest, a greater stability is introduced into the local and regional system. This contributes to national self-reliance for the critical element, food.

Emphasize Food Production in Place of Export Crops

A high priority for policy makers, researchers, extension specialists, and farmers should be to encourage production of basic food commodities. Economies of scale for production of export crops, the comparative advantage of growing these crops in an appropriate climatic regime, and the serious need for foreign exchange has kept many countries dependent on a number of commodities which do not contribute directly to local food supply. Although export and participation through international markets will continue to be important to development strategies, there are some serious problems with overemphasis on this sector. Given the instability of international politics and economic price structures, each country must seek some degree of self-reliance in basic food commodities.

Governments can encourage production and direct consumption of food crops through import and export policies, by realistic price supports for basic food crop production, and with financial incentives to farmers. The research agenda can be shifted to emphasize food crops and the cropping systems in which they are grown. This would be a radical departure from current policies and development strategies in some countries, but the problem of food needs to be given priority in each country in a manner which is consistent with resources and potential food crop production. International and bilateral assistance programs also need to encourage this emphasis on basic food crops.

Use Information and Management Intensive Technologies

The efficient use of resources which are internal to the farm requires careful study and indepth understanding of the farming system and climate in which it operates. Emphasis on legumes, crop residues, and manure as principal sources of nitrogen and alternatives to expensive purchased chemical fertilizer requires a practical understanding of how crops grow and use resources. Integrated pest management using rotations, crop and variety choice, intercropping, and genetic resistance to pests requires a more precise management than systems which rely on domination of the pest environment through application of chemicals. In each case, the farmer is substituting information and management skills for expensive purchased inputs. This means that the research and extension establishment must work more closely with the farmer to blend traditional farming experience and conventional cropping wisdom with the potentials of modern science to develop new management alternatives. Although there is a degree of sophistication needed by the farmer to implement such practices, this type of management expertise builds on what the farmer already knows about the natural environment and how crops and animals interact with that environment. The net result is a substitution of information and management for expensive imported and energy rich production inputs, and the product is an alternative farming system which is more sustainable within the resource constraints of the farmer.

Integrate Food Production, Nutrition, and Health

One valuable attribute of many traditional farming systems is the integration and interdependence of food production, family diet, and nutrition. Whether through design or through need, the success of food related activities determines in a direct and real way the health and well-being of the farm family. If food production potential is reduced or removed from a rural family the effects can be major and long-lasting. Small farmers in several communities in

the southern Cauca Valley in Colombia traditionally produced a wide range of food products for family consumption and sale in an intercropped combination of perennial and annual species. When they were offered attractive prices for these small parcels along with a promise of jobs in the sugar cane fields which would replace the subsistence crops, this change appeared to offer income security, improved nutrition, and a better way of life. In reality, these families became highly dependent on the large company which owned and managed the sugar enterprise, were now subject to world prices for this somewhat volatile commodity, and also found themselves dependent on food from other food sources which at times was not available at prices the family could afford. They had moved from a comfortable and independent subsistence situation with some extra product to sell to a highly dependent and insecure economic situation which directly affected food supply, nutrition, and health. A strategy is needed which includes a high degree of self-reliance in food production at the family and community level, and which extends to rural areas the infrastructure required for improved health care. This strategy can be consistent with preserving and improving traditional cropping patterns and land ownership, where many families in a region preserve the potential for food and income generation.

Build Toward a Regeneration of the Production Resources

In contrast to those systems which dominate the production environment through applications of soluble chemical fertilizers and pesticides, which apply large quantities of irrigation water, and which otherwise require large amounts of outside energy to successfully produce crops, a regenerative agriculture has potential to both sustain production and improve the soil resource. By introducing crop rotations, annual or perennial legumes, and non-chemical methods of pest control into a cropping system the farmer will precipitate some basic changes in soil organic matter, soil structure, and population of microorganisms. Although these changes are not well understood, they appear to provide new potentials for the cycling of nutrients in a non-chemical or reduced chemical input system. The fate of nitrogen, phosphorus, and other elements is under study in non-chemical and conventional systems to determine the major differences between these two alternatives and how these differences can be exploited by farmer management. The increase in soil organic matter which occurs in more intensive intercrop systems provides a fertility buffering mechanism by bringing nutrients up from lower soil strata, tying up nutrients in the organic fraction, and cycling nutrients through crop residue into a succeeding crop. The reduction or elimination of applied pesticides promotes an increased population of parasites and predators which help control crop pests in a more ecologically benign way. These practices contribute to enhanced soil fertility and a production environment which can be sustained in a manner more consistent with the resources available to the small farmer. With the drastic reduction of pesticides in the production system, there is less danger of food contamination, accidents with chemicals on the farm, and residues in food products. This approach is becoming known as regenerative agriculture.

Translating Biological Efficiency Into Management

Understanding the biological structuring and interactions of a farming system is the first step toward designing new management strategies which take advantage of these relationships. Many of the regenerative practices which are currently used by some farmers in both developed and developing countries provide insight on how biological systems can work effectively. Maize produced in

rotation with legumes and with applications of manure on a Pennsylvania beef cattle farm has yield levels equal to or greater than comparable nearby farms which use conventional chemical practices. Energy inputs are about twice as high in the conventional farming pattern. A three crop relay system of potato/maize/bean in Antioquia, Colombia uses added fertilizers only on the potato crop to achieve yield levels of all three crops well above the national average, and provides greater land use efficiency and income than monoculture systems. These are examples of highly structured systems which take advantage of biological interactions among plant species to provide for fertility and crop protection.

Although energy and chemical costs can be substantially reduced in these alternative systems, the complexity of highly structured systems may require greater amounts of management information and farmer expertise. Management needs to exploit the biological interactions between intercropped plant species and between crop and animal species which cohabit a farming system. Efficient biological structuring in these interactions is not happenstance. Farmers who have developed these systems over the years have observed which combinations prosper and provide compatibility in use of limited resources rather than competition under limited input management. The collection and evaluation of this empirical experience and conventional wisdom about cropping systems is becoming more important in the research agendas of some organizations, including those which deal with the farmer in a farming systems context. When the knowledge of these interactions is linked with technical principles developed through research and observation, a series of new options can be developed for the management of resource efficient farming systems.

A farming systems approach which involves the farmer and family in identification of constraints and design of new options is well suited to exploiting internal resources and biological structuring of cropping systems. In the past many of our development strategies have been characterized by top down planning and decision making. Often this approach has resulted in grandiose production plans which build on data and experience from other countries or regions, and at times the conclusions were not consistent with the local constraints and resource base. When the farmer is involved in planning, there is a greater chance that proposed farming strategies will lead to solution of real constraints and an improvement in production, nutrition, and income in the rural sector. There is a built-in participatory mechanism which will help the adoption of the new management strategies by farmers in the region. Systems which are designed by researchers together with farmers who understand the natural and production environment within which they operate have a greater probability of taking advantage of the internal resources on the farm and the knowledge of biological structuring which is a part of the farmers' experience. We all share responsibility for the design and promotion of farming systems which are appropriate for the farmer with limited resources, and together with farmers in all parts of the world can work toward systems which make most efficient use of internal resources and have a minimal effect on the environment. This is one viable route toward a sustainable food production system for the future.

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STRATEGIES FOR INTEGRATING ENVIRONMENTAL ASSESSMENT INTO FARMING SYSTEMS RECONNAISSANCE ENDEAVORS

Gordon Matzke, James Pease, Robert Vincent

INTRODUCTION

The United States Government is committed to considering the environmental consequences of its actions by the requirements of the National Environmental Policy Act (NEPA). Domestically, this act and subsequent court interpretations have transformed the way most federal agencies go about their business. This transformation has opened up their decision making to public scrutiny and forced them to make a "state of the art" accounting of the expected environmental impacts of major actions. This public accounting did not come easily, or voluntarily, to most agencies. Within the United States, a large number of citizen "watchdog" groups have used the enforcement power of the courts to ensure compliance. Perhaps because it labors in relative obscurity overseas, the U.S. Agency for International Development (USAID) has yet to evolve a structure which really meets the test of NEPA's spirit for all of its programs. This paper outlines a means by which environmental analysis can be incorporated into the farming systems research program. The premise is that environmental analysis can not only provide real project benefits but prevent serious problems to project beneficiaries if conducted early in the decision-making process.

USAID'S RELATIONSHIP TO NEPA

All of USAID's activities are not subject to the requirements of the National Environmental Policy Act. However, expenditures for development assistance, including farming systems research and extension (FSR&E), are subject to NEPA scrutiny if they are judged to be major federal actions with a significant impact on the environment. Though FSR&E activities may initially fall under a USAID environmental Categorical Exclusion (USAID; 1980) because of their limited scope, FSR&E results, expanded to a wider recipient group, would certainly be subject to USAID environmental assessment procedures. In its 1985 report to Congress, USAID recognized the need to ..."link its agricultural development activities with its environmental management activities..." and emphasized "...the necessity for environmental assessments in agricultural planning...". (McPherson, 1985, p. 257).

In another policy paper, USAID states that "Environmental analysis is most effective when incorporated at the earliest possible stage in project identification along with economic, social, institutional, energy, and other technical analyses."; and "Additional environmental guidelines should be developed as a priority for the energy and agricultural sectors by the responsible technical offices in the Bureau for Science and Technology". (McPherson, 1983, p.3). Thus, the issue is, how can USAID environmental assessment procedures be integrated into the FSR&E process? Such an integration would not only accomplish the goal of compliance with NEPA, but just as importantly, it would enchance FSR&E decision making with respect to increasing farm family welfare in the long run. Prior to discussing the central issue of this paper, it will be useful to look at the characteristics and activities of FSR&E and then at USAID's environmental assessment procedures.

CHARACTERISTICS AND ACTIVITIES OF FSR&E

According to Shaner (1982), there are six characteristics of FSR&E. These are:

1. FARMER BASED. FSR&E has as its basis the farm family and the environment within which the farmer operates.

2. PROBLEM SOLVING. FSR&E is applied research in that it seeks solutions which are readily available to the farmer. FSR&E tries to deemphasize solutions which require national government intervention or costly techniques beyond the farmers immediate financial capability.
3. COMPREHENSIVE. FSR&E is a systems approach studying the whole farm environment. The systems approach is necessary because such an approach readily identifies those areas which are classified as being the most limiting to increasing farm production.
4. COMPLEMENTARY. FSR&E is complementary with commodity and disciplinary research since it acts as a conduit between farmers' problems and research results.
5. ITERATIVE AND DYNAMIC. FSR&E must focus on the entire farming system in order to achieve results which can be applied to other similar farming systems. Thus the FSR&E approach is continually modifying its design to achieve maximum results for the farmer.
6. RESPONSIBLE TO SOCIETY. Though FSR&E is farmer focused, the results of FSR&E must be in accord with national policy and objectives. In addition, FSR&E can provide information to national policy-makers so that government resources may be marshalled and targeted for maximum results.

The above characteristics are manifested in the following FSR&E activities. These activities are carried out by interdisciplinary field teams and include:

1. Geographic area and target farm selection;
2. Problem identification and development of a research base;
3. Planning on-farm research;
4. On-farm research and analysis;
5. Extension of results.

For an in-depth discussion of FSR&E characteristics and activities, the reader is referred to Shaner's book; but for our purposes its important to see their commonality with environmental procedures.

USAID ENVIRONMENTAL PROCEDURES

Since its inception in 1969, the procedural and substantive requirements of NEPA have been refined by court decisions, amendments to the law, Council on Environmental Quality (CEQ) revised regulations, and agency experience. The term environment has been broadened to encompass social, economic, and cultural concerns as well as the ecological, physical and resource concerns of environmentalists.

NEPA procedures have been streamlined and clarified to reduce paperwork, reduce delay, and improve decisions. The improved procedures are a means to providing more agency direction and accountability for compliance with the law's substantive intent. The key substantive objective is a full consideration of significant impacts associated with a reasonable range of alternatives. The quality of analysis, and of decisons based on the analysis, depends largely on the identification, prediction, and evaluations of these impacts. The analysis must take a systems view which includes direct, indirect, and cumulative impacts; probability of occurrence; duration; magnitude; mitigation measures; and risk assessment.

The USAID environmental assessment process begins at the Project Identification Document (PID) stage where an Initial Environmental Examination (IEE) is prepared. The IEE is a statement as to whether an Environmental Assessment (EA) or an Environmental Impact Statement (EIS) will be required (USAID;1980). Based upon the IEE, a Threshold Decision, along with the PID, is reviewed by the Bureau Environmental Officer who will either concur with the Threshold Decision or request reconsideration (USAID;1980). If the project is considered to have significant impact on the environment, a Positive Threshold Decision is made. At this time, the project originator begins the Scoping process (USAID;1980).

Once the significant issues of the project are identified through the Scoping process, the EA or EIS is prepared. The EA or EIS becomes an "integral part of the Project Paper (PP) or equivalent document" (USAID;1980). Most importantly, "...final approval of the PP ...and the method of implementation will include consideration of the Environmental Assessment or final Environmental Impact Statement" (USAID;1980).

A close look at FSR&E characteristics and USAID environmental assessment procedures reveals a number of similarities. These will be discussed in the next section.

SIMILARITIES BETWEEN FSR&E AND USAID ENVIRONMENTAL PROCEDURES

There are a number of characteristics shared between FSR&E and the environmental assessment procedures of NEPA and USAID. These shared characteristics are:

1. IDENTIFICATION OF INTERACTIONS. In both FSR&E and environmental assessment procedures, it is imperative that social, economic, and physical environmental interactions be identified. The analysis of these interactions provides the basis for developing on-farm research projects as well as for assessing potential environmental impacts of project activities.
2. RANGE OF ALTERNATIVES. Integral to both FSR&E and environmental assessment is the identification and analysis of alternative actions. As Shaner (1982:89) points out,

   Before deciding on a particular approach, the FSR&E team should consider the alternatives. Failure to consider the better alternatives will produce inferior results no matter how well the experiment is designed.

   Likewise, CEQ Guidelines (1978) and USAID Environmental Regulations (1980), call for the evaluation of reasonable project alternatives and how each would affect social, economic, and natural environments.
3. SCOPING. Though not explicitly stated in FSR&E guidelines, the approach used in the FSR&E process is similar to the "scoping" process as required by CEQ Regulations (1978) and USAID Environmental Procedures (USAID; 1980). Basically, the Scoping process is done by an interdisciplinary team which ascertains the pertinent research topics to be addressed in the environmental document (either an EA or an EIS). In the case of the FSR&E process, the interdisciplinary team identifies farm system interactions which lead to on-farm research alternatives. FSR&E would, as now practiced, be concerned with environmental impacts only insofar as they might have

consequences for farmers. Environmental assessment scoping requires a look at all "significant" impacts, regardless of who, or what, will suffer the consequences.

4. MULTIDISCIPLINARY APPROACH. In both procedures, a multidisciplinary approach is taken. As Shaner (1982) points out: Because of the comprehensive approach and interactions of many technical and human factors, FSR&E teams should be interdisciplinary. By interdisciplinary, we mean frequent interactions among those from different disciplines who work on common tasks. From this should come better results than had they worked independently.

Similarly, the CEQ Regulations (1978:sec.1502.6) state: Environmental impact statements shall be prepared using an interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts.

INTEGRATING USAID ENVIRONMENTAL ASSESSMENT INTO THE FSR&E PROCESS

Though there are a number of similarities between the FSR&E process and USAID environmental assessment procedures, just exactly how might the two be integrated? Our suggestions are summarized in Figure 1.

First, the environmental assessment process must become an integral part of the FSR&E approach. The most effective way to do this is through the scoping process. Which isolates those issues which are deemed paramount to the project. The process includes identification of potential environmental impacts and their interactions, the likely significance of the impacts, and possible project alternatives or mitigation strategies. The scoping process could best be adapted to the "Problem Identification" stage of the FSR&E process. According to Shaner (1982), it is at this stage that the interdisciplinary team:

1. identifies existing farming systems and seeks to understand them and the environment;
2. identifies problems and opportunities for improving the system, the environment, or both;
3. sets priorities for research and implementation.

Second, in order to adapt the scoping process to the FSR&E "Problem Identification" stage, an assessment methodology must be developed. Assessment methodologies are used to identify potential environmental impacts of project activities. They are also useful in identifying the interaction between the potential impacts. Possible formats for the assessment methodology are presented in the next section.

Third, once potential impacts are identified, they must be evaluated as to their significance to the project. Proposed criteria are discussed in a subsequent section of this paper.

ASSESSMENT METHODOLOGIES

Several methodologies for impact identification are available, including checklists, matrices, stepped matrices, and systems analysis. (Canter, 1977; Westman, 1985; Hollings, 1978). For FSR&E, a combination of two techniques

could be adapted. For the initial stage, the scoping concept developed by the USDA Cooperative Extension Service (Smardon, et al., 1976) provides an assessment form, manual, and resource handbook which, used together, offers three "filters" to assure that impacts are fully identified (Figure 2).

The first filter is a review of the relevant legal constraints, which may preclude or limit certain alternatives. The legal review includes statutes (U.S. & host country), court decisions, executive orders and internal agency policies. For example, USAID's internal policies include:

> "To ensure the environmental soundness and long term sustainability of AID's assistance programs and projects"; "...long term benefits to the world's poor...must be based on environmentally sound planning and on a clear understanding of a country's natural resource potentials and limitations. (McPherson, 1983, p.1).

In 1983, the U.S. Congress directed USAID to develop policies and programs to protect and conserve biological diversity in developing countries. Other major issues addressed by internal policies include use of pesticides, deforestation, soil conservation, and air and water pollution (Printz, 1984).

The second filter is an assessment form which is organized by thirteen topical headings, such as natural hazards, community structure, and local and regional economics. The format provides for a checklist of impact type (direct or indirect), duration, reversibility, and severity.

A third filter is a checklist of impact generators and their potential direct and indirect impacts. For example, range improvements could cause water pollution from chemicals and animal waste which could lead to health problems; change the plant cover composition leading to erosion and sedimentation; change the feeding, bedding, and breeding habitat of wildlife, etc. These impact generator checklists can be easily prepared for activities common to FSR&E. (Sorensen, 1973; Smardon, et al. 1976).

Once the major types of impacts have been identified, a second useful technique to employ is a matrix (Figure 3) as a way to trace and display the magnitude of effects of project actions. The mechanics of developing such a matrix are documented in a number of sources (Canter, 1977; Hollings, 1978; Westman, 1985), although none address the particular circumstances of F.S.R. & D.

EVALUATION CRITERIA

Once potential impacts are identified, it is necesary to array them in some order of significance. For this purpose an evaluation criteria guidebook is useful. The guidebook would aid the impact assessment scoping process by spot-lighting the types of impacts deemed most significant by host-country and USAID project personnel. For example, general USAID objectives of soil conservation, protection of biological diversity, prevention of desertification and deforestation, and safe pesticide use can be stated as evaluation criteria.

Other criteria which are implicit in the FSR&E program include preservation of family and community cohesion, ensuring that the proposed project will not adversely affect the health or safety of local people, and a concern for the future economic stability of the target areas, at least as it relates to project effects. For example, an action that could set in motion a series of land tenure changes may result in land ownership concentration over a 10-20 year period, causing economic stress on the original target population.

Though implicit in the scoping process, it is important to underline the necessity of host country participation in the entire process, especially in developing evaluation criteria since the evaluation of the significance of an impact and the need for corrective measures is essentially a matter of social choice. Though other factors enter into the evaluation phase, including USAID internal policies and the policies and laws of the host country, social customs and traditions, though not necessarily written into law, may also be important in the evaluation phase. Thus without close host-country participation, there is a danger of omitting an evaluation criterion which may be crucial for project success.

The relative importance of a potential impact will also depend on several other factors, including probability of occurrence, reversibility, degree of interaction (i.e. indirect and cumulative effects), and potential for mitigation. These factors will need to be incorporated into the evaluation guidebook.

Evaluation criteria would make the scoping process more efficient, consistent, and applicable to the country's needs. They would also help accomplish the USAID objective of integrating environmental considerations into long-term planning programs and bring the agency closer to compliance with both the letter and the spirit of the National Environmental Policy Act.

DISPLAY OF RESEARCH PRIORITIES

While it is unavoidable that the weighing of all of these elements will be, to some extent subjective, the scoping report should explain the basis for relative rankings. The purpose, in the end, is to establish a research agenda for an in-depth environmental analysis and evaluation. A scoping process, by definition, is similar in this respect to the preliminary reconnaissance of the FSR&E process.

CONCLUSIONS

One of USAID's environmental policy objectives is to ensure environmentally sound assistance programs and projects, leading to the overall Agency goal of economic development in LDC's. Since the FSR&E goal is to increase farm family welfare, the two goals are quite compatible. To attain these goals, it is necessary for decision-makers to have a comprehensive method for assessing the farmers environment, the potential alternatives for improving that environment, as well as the impacts of those alternatives. By integrating environmental assessment with FSR&E, decison-makers would move toward a more comprehensive method.

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LIST OF ACRONYMS

CEQ = COUNCIL ON ENVIRONMENTAL QUALITY is the agency which reviews compliance with the National Environmental Policy Act.

EA = ENVIRONMENTAL ASSESSMENT is a document which fully discloses the expected impacts of federal actions which are not deemed "major" by the definition of the National Environmental Policy Act.

EIS = ENVIRONMENTAL IMPACT STATEMENT is a document required by the National Environmental Policy Act and is intended to fully disclose the expected environmental impacts of proposed major federal actions.

FSR&E = FARMING SYSTEMS RESEARCH AND EXTENSION, sometimes referred to as
FSR&D or Farming Systems Research and Development.

IEE = INITIAL ENVIRONMENTAL EXAMINATION is a preliminary assessment of the impacts of a proposed action. It is used to determine whether a full Environmental Impact Statement, or its alternative, the Environmental Assessment, is required.

NEPA = NATIONAL ENVIRONMENTAL POLICY ACT

PID = PROJECT IDENTIFICATION DOCUMENT is a preliminary description of a potential USAID project.

PP = PROJECT PAPER is an in-depth description of a potential USAID project.

USAID = UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

USDA = UNITED STATES DEPARTMENT OF AGRICULTURE

SCHEMATIC OF F.S.R.&D. AND ENVIRONMENTAL ASSESSMENT PROCESSES

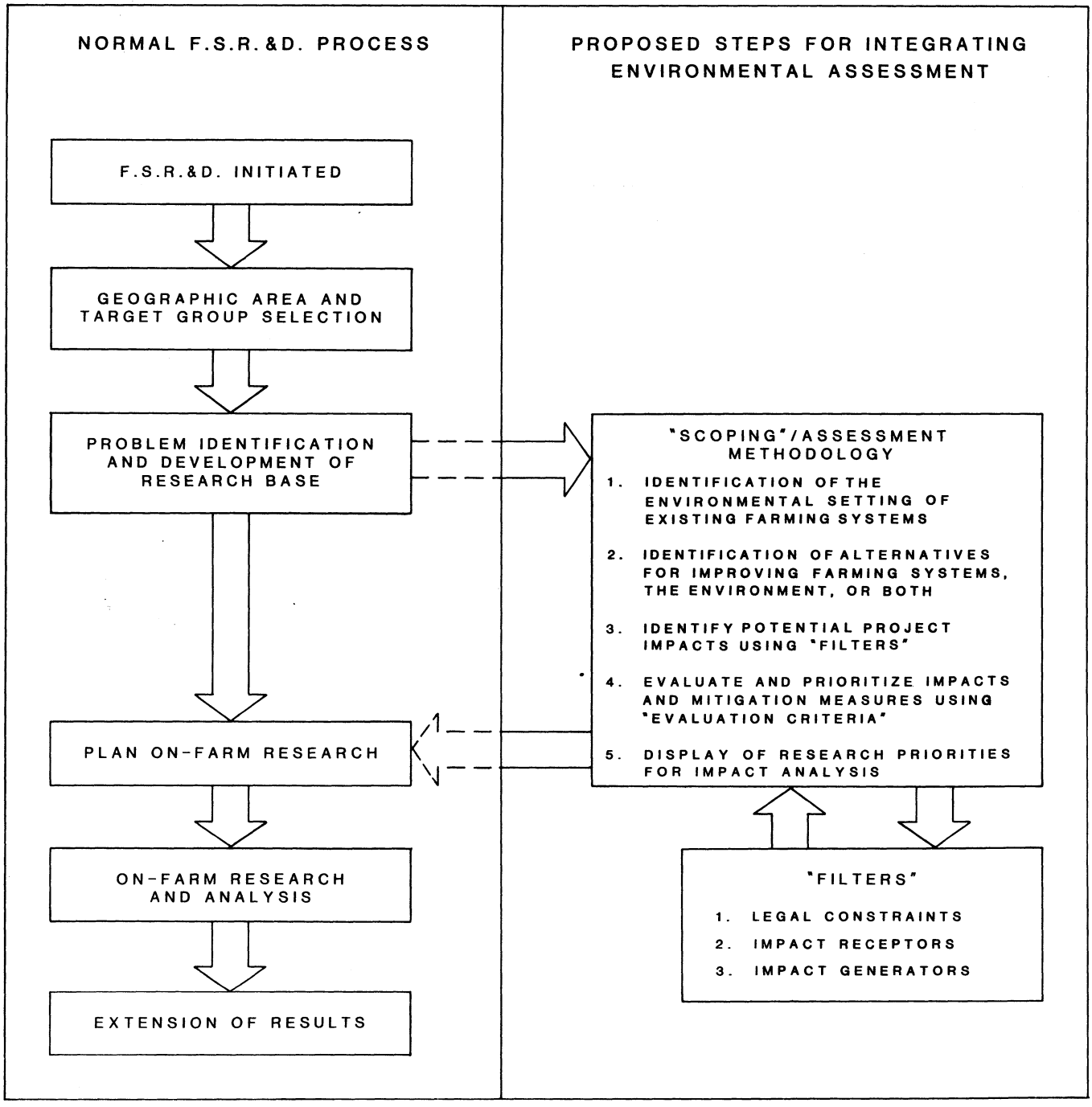


Figure 1

THE PROJECT "SCOPING" PROCESS USING THREE FILTERS TO IDENTIFY POTENTIAL ENVIRONMENTAL IMPACTS OF FARMING SYSTEMS RESEARCH AND DEVELOPMENT UNDERTAKINGS

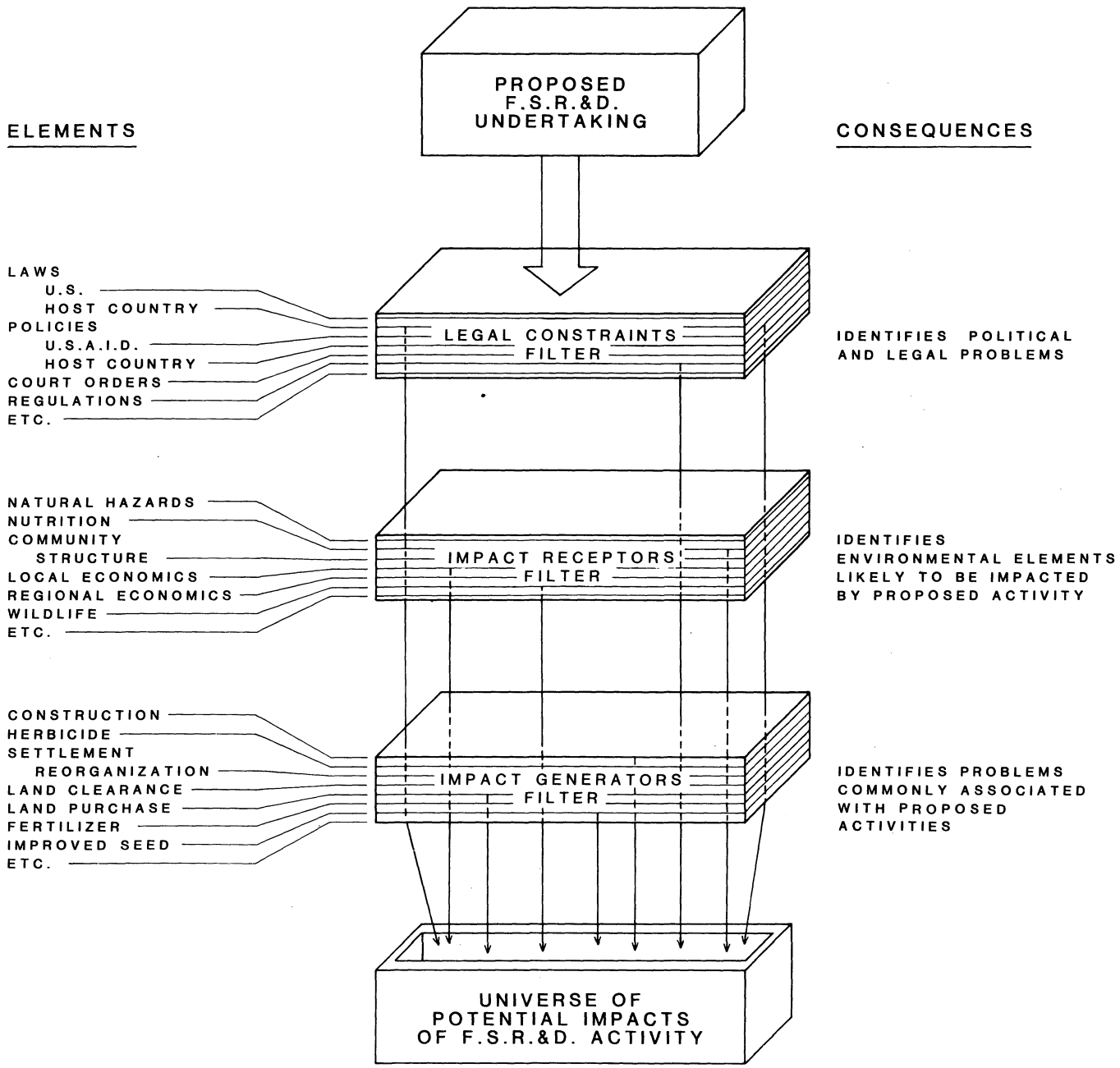


Figure 2

EXAMPLES OF MATRIX COMPONENTS
FOR
FARMING SYSTEMS RESEARCH & EXTENSION
FIELD RECONNAISSANCE ENVIRONMENTAL ASSESSMENT

	ELEMENTS	IMPACT PERIOD		
		RESEARCH PHASE	EXTENSION PHASE	INSTITUTIONAL PHASE
ENVIRONMENT	ELEMENTS	-	o	0
	SOIL EROSION	-	o	0
	WILDLIFE DIVERSITY	-	o	o
	GROUND WATER QUALITY	-	-	-
	VERMIN DENSITY			
FARM FAMILY	COST OF FARM INPUTS	o	0	0
	INCOME FROM CROPS	+	*	*
	DIETARY NUTRITION	+	*	*
	EXPOSURE TO CHEMICAL HAZARDS	-	-	-
	DRINKING WATER QUALITY	X	X	X
REGION & NATION	FOREIGN EXCHANGE EXPENDITURES	o	0	0
	FOREIGN EXCHANGE RECEIPTS	-	+	X
	CONGRUENCE WITH NATIONAL PLAN GOALS	*	*	*
	LAND TENURE CHANGES	-	-	X
	LAND USE CHANGES	-	-	-

LEGEND

- o indicates minor negative impact
- 0 indicates major negative impact
- + indicates minor positive impact
- * indicates major positive impact
- X indicates an undetermined impact
- - indicates no appreciable impact

Figure 3

The Inclusion of Time Factors in the Design of On-Station and On-Farm Trials: A Case Study from Kilosa District, Tanzania

Larry S. Lev

INTRODUCTION

It is perhaps the critical importance of time related elements which most clearly differentiates agricultural production from industrial production. Whereas production schedules within industry can be set by man, in agriculture these schedules can only be established within the parameters permitted by nature.

Within the field of agricultural research, much work in recent years has concentrated on studying production activities in a systems context. This may take the form of either formal mathematical models or less rigorous tools such as crop calendars and flow charts which serve the same purpose. In all cases it has been found that when the time elements are more carefully taken into account it becomes possible to better understand and predict farmer reaction to proposed innovations (Norman,1980; Crawford,1982; Delgado, 1979; Hankins, 1974).

Despite the demonstrated advantages of this holistic approach, much agricultural research is still based upon the reductionist approach of focusing on one or two elements while attempting to control all others. In this paper the experience which a farming systems team working in Tanzania has had in transforming the approach to research in a specific district will be discussed with the particular reference to the issue of timing.

The Tanzanian Agricultural Research Organization (TARO) is a parastatal that has a broad mandate to conduct both food and non-food crop research throughout most of Tanzania. Research within TARO is organized on a commodity basis with a single coordinator setting the research priorities for each crop on a nationwide basis. With limited resources (especially foreign exchange) these research programs have done a commendable job. In late 1983 in collaboration with USAID, a Farming Systems project was launched which has as its major thrust the attempt to ensure that the research carried out by TARO scientists would be more relevant to the client groups to be served. At that time, the personnel within TARO were virtually all biological and physical scientists with little training in the methodology of the farming systems approach.

The objective of the Farming Systems Research and Extension (FSR/E) approach is to transform the research process so that the farmer rather than the researcher is at the center. Specifically this requires taking into account farmer constraints, opportunities, and preferences. The achievement of these objectives requires a multi-stage research process which proceeds from system description and diagnosis, to experimental design and testing and finally to the extension of the new technologies (Byerlee, D. et al., 1980; Shaner et al., 1982).

In particular, the concept of time has been introduced as a key consideration in the re-orientation of the TARO commodity research programs. It is clear that the temporal dynamics of peasant decision making has been a if not the main focus of FSR/E work. This paper recounts the small yet significant steps which the FSR/E team within TARO has made towards the integration of previously ignored timing considerations into the on-going research programs.

THEORETICAL FRAMEWORK

Specifically four time related elements should be taken into account:

1. The amount of farmers' time required to implement the proposed innovations;

2. The periods in which time is required;

3. The variability in the outcomes of the proposed innovations over time;

4. The sustainability of the proposed innovations over time.

The importance of timing considerations becomes apparent when the proposed innovations are put through the prescreening process As outlined in Anandajaysekram (1983), the solutions which researchers propose for the modification of existing production systems are screened for three criteria:

1. Economic viability

2. Riskiness

3. System compatibility

The first, economic viability, is in many respects the easiest for the agricultural researchers to comprehend and integrate into their analysis. Since most of them farm themselves they realize that it is the net return earned rather than the achievement of the biological potential of the individual crops which must be the goal of the technological packages which they design. Although the scientists understand the principle behind this change they still may not be well qualified to carry out the necessary economic analysis. Specifically they may not be well versed in assigning costs and prices to the changes in inputs and outputs which occur. As is detailed below, many of the pricing problems occur in determining the appropriate price at different points in time. The more complex issue of the opportunity costs associated with time related resources is considered under system compatibility below.

Risk is a somewhat more difficult concept for the biological and physical scientists to handle. All of them are certainly familiar with the concept of variability from their work in statistics but the existence of risk necessitates an understanding of its psychological complications. Another complication is that although some understanding of risk can be developed by examining the experiments on a commodity by commodity basis, in order to truly grasp the concept it is necessary to look at the whole system since ordinarily one would expect the farmer to consider the whole system in terms of riskiness rather than each individual part. The models which have been developed in the various disciplines range from the simple to the very complex (Hey, 1979). Still even relatively simple concepts such as "risk premiums" can go a long way towards explaining which proposals will be acceptable to farmers.

Systems compatibility is the third and most difficult concept to integrate into the traditional technology design process. This is the concept which most directly relates to the idea that the farmer is operating a system which has an internal logic over time and space. The breadth of this concept is difficult to

grasp for the commodity researcher who has been taught to view the world in a compartmentalized fashion. While the systems compatibility concept covers a variety of issues, it revolves primarily around the determination of the opportunity costs associated with the alternatives uses of the land, labor, and capital resources available to the farmer in specific time periods.

TIME CONSIDERATIONS

As a start it is useful to consider exactly which things vary over time and how many of them can and should be included in the analysis. First a distinction can be made between short and long term variations.

TIME CONSIDERATIONS WITHIN A SINGLE YEAR TIME HORIZON

1. Weather
   a. Rainfall
   b. Sunlight
   c. Temperature
2. Insects
3. Vermin
4. Crop diseases
5. Soil conditions
6. Availability of capital
7. Availability of inputs
8. Availability of food
9. Availability of household labor
10. Price of agricultural products (purchase and sale)
11. Price of hired labor
12. Use of land for double and/or intercropping
13. Flexibility of planning

TIME CONSIDERATIONS OVER A LONGER TIME HORIZON

1. Climate
2. Soil conditions

a. fertility

b. erosion

3. Availability of land

4. Political and economic changes

5. Flexibility of planning

Only a few of these time related considerations are commonly taken into account by commodity researchers who look at the world on an experiment by experiment basis. These are the time factors which directly influence yield (listed as 1-5 under the "single year" horizon). Since on-station conditions may differ greatly from on-farm conditions it is difficult to examine even these satisfactorily. The remaining issues listed under the "single year" horizon and all of the items under the "longer term horizon are even less likely to be taken into account during the process of evaluating new technologies on the research station.

RESEARCH PROCEDURES AND BACKGROUND TO THE STUDY AREA

FSR fieldwork was initiated in Kilosa District in late 1983 with a diagnostic survey carried out by a group of researchers under the direction of Dr. Alex Cunard (Cunard et. al., 1985). Subsequently, in July/August 1984 a verification survey was conducted in seven villages in Kilosa District (Lev, 1985). Based upon these activities and several subsequent planning sessions held at Ilonga A.R.I. in September and October of 1984 an experimental program was established for on-farm trials to be planted in November 1984, February 1985, and July, 1985. The experiments selected were intended to address major problems and opportunities in the existing farming system.

Figure 1 presents an overview of the study area. Kilosa District is located in the northwestern part of Morogoro region and has good road and train links to the important Dar es Salaam and Dodoma markets. It lies between six and eight degrees latitude and the majority of the land area is approximately 500m above sea level.

The FSR soils chemist, Mr. I.R.O. Mhando (1985), has characterized the area covered by the on-farm research as being divided into four land systems. These land systems depict soil and land form characteristics which differ and may influence crop growth. (1) The hilly region to the south possesses deep brightly colored and well drained soils which offer the possibility on crop production on its summits, midslopes, footslopes, and valley bottoms. Soil erosion is quite evident in this area. (2) The flat lowland plain (the Mkata Plain) is characterized by dark colored, moderately developed, poorly drained soils which are subject to waterlogging. (3) The undulating lowland plain (also part of the Mkata Plain) is characterized by deep well drained soils suitable for large scale mechanization. (4) A final, relatively smaller area consists of shallow depressions that are found on the undulating lowland plains and are characterized by dark colored poorly drained cracking clays which are difficult to cultivate when dry and are also subject to waterlogging.

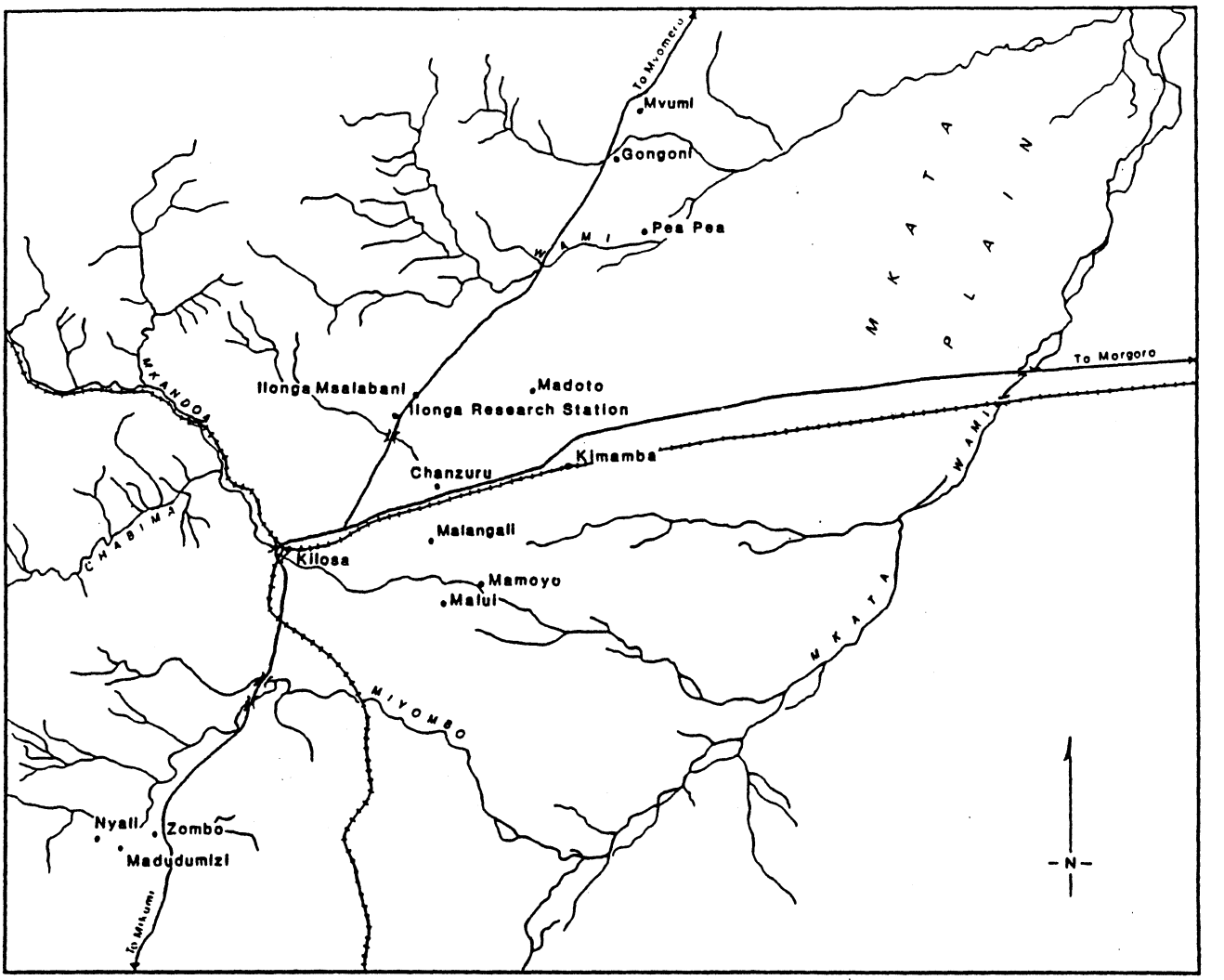


Figure I: Map of Kilosa District Experimental Sites (1984/1985)

The soils found in all four classifications are generally fertile. They have relatively high levels of organic carbon (3.06%) and have ranges of ph that favor the availability of most soil nutrients to the plants.

Kilosa District is blessed with a long although somewhat unpredictable bimodal pattern of rainfall which stretches from November through May. In most sites the average annual rainfall surpasses 1000 mm per annum. Farmers commonly distinguish between the short rains (Vuli) which last from November through early February and the main rains (Masika) which extend from mid-February through the end of May. Over the last twenty seven years at the Ilonga Research Station the short rains have averaged 431 mm and the main rains 608 mm. In addition the greater reliability of the main rains is reflected in their coefficient of variation of 0.28 as compared to a figure of 0.45 for the short rains. their coefficient of variation of 0.45 versus the figure of 0.28 for the main rains. The reliability and amount of the short rains decreases as one moves from south to north in the District. Ordinarily a dry period of two to three weeks occurs during the month of February and separates the two rainy seasons. The average monthly rainfall and the 1984-1985 rainfall totals are presented in Figure 2.

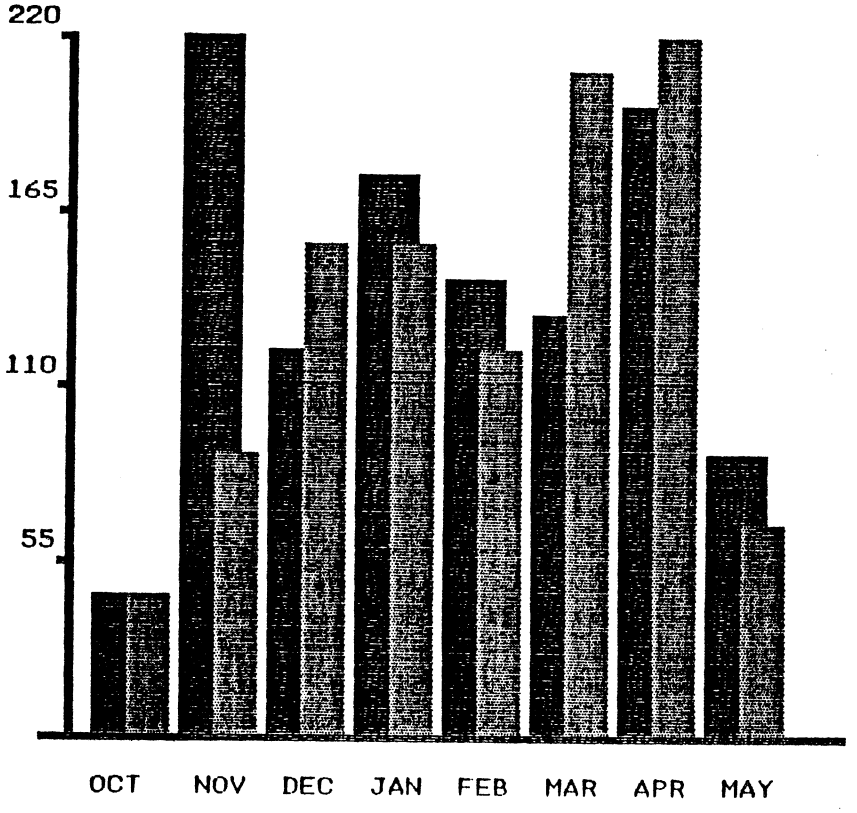
FIGURE 2: 1984-1985 & LONGTERM RAINFALL BY MONTH FOR ILONGA A.R.I. (in millimeters)

SHADING:

1984-1985 -- dark

longterm -- light

source: Ilonga A.R.I.



The lack of consistency in rainfall can be seen by examining the relationship between the short and main rains within individual years. In 14 of the last 27 years at Ilonga A.R.I.. the short rains have been above average. In six of those years (43%) the main rains were also above normal while in eight of those years the main rains were below normal. In eight of the thirteen years

for which the short rains were below normal the main rains were also substandard, while in the other five years the main rains were above average.

As one moves from south to north in Kilosa District the amount of rainfall decreases and the start of the rains is delayed. The FSR team at Ilonga defined three zones (southern, central, and northern) based upon the combined factors of soils and climate. As is described in greater detail below , in the southern zone there are three distinct growing seasons as a great deal of production takes place in valley bottoms during the dry season. In the central zone the farmers place a heavy dependence on food production in the short rains and produce cash crops during the long rains. Finally in the northern zone, neither rainy season is dependable so food crop production takes place equally in each of them.

Despite what the farmers are doing around them, all of the commodity research programs at Ilonga A.R.I. (which is located in Kilosa District) have focused their on-station experimental programs on crop production during the main rains. Little attention has been given to production practices during the short rains and no research effort has been devoted to crops grown during the dry season on residual moisture. A number of explanations for this tendency can be put forward. First, the greater and more reliable rainfall during the main rains makes it more likely that "optimal" yields will be achieved during that season. Secondly, if crops are planted during both seasons it becomes much more complicated to manage the overall research program. An additional reason may be that the current planning cycle for the on-station experiments revolves around a crop coordinators' conference which is held in late October or early November, and hence can not be used as a forum for the discussion of short season experiments.

Thus, the research programs have been motivated by the general goal of optimizing the production of individual crops rather than by specific objectives of farmers. As is demonstrated below this often causes them to work on issues which are not of particular interest to the farmers.

The farmers view their system and in particular the agricultural calendar in quite a different fashion and make full use of both rainy seasons as well as in many cases the opportunities to grow crops on residual moisture during the dry season. Farming in all parts of Kilosa District is quite diversified, with an average of eight crops grown per household, and fairly extensive, with the average household cultivating 2.42 ha. The cultivated area is split into an average of 7.6 separate fields. Although this poses management problems it also permits the majority of farmers to raise crops in a variety of environments.

The hand hoe is the principal work implement used although 20% of the fields are plowed with hired tractors and the demand for increased access to tractors ranks number one on farmers' lists of demands. The use of animal traction is exceedingly rare as is the keeping of cattle by the settled farmers. As a result there are few interactions between crop and livestock enterprises.

Aside from improved seeds (mostly maize) which are purchased by 20 to 30% of the farmers in a given year it is rare for farmers to purchase other inputs such as fertilizers or herbicides. One exception is the use of insecticides in cotton production.

Crop performance varies widely among farmers in a given year as well as from year to year. The within year variations can be attributed to variations in soil fertility, management levels (especially timely weeding), and hazards such as insect, disease, wild animal, and Maasai cattle attacks. Between years the most significant cause of variations in production is the level of rainfall.

Given all these sources of variation it is not surprising that the farmers choose to follow such a diversified pattern of production. The three main crops in the system are maize, rice, and cotton. The minor crops which are grown (cowpeas, sorghum, cassava, bananas, sugar cane, sesame, beans, and coconuts) fit in around the three main crops.

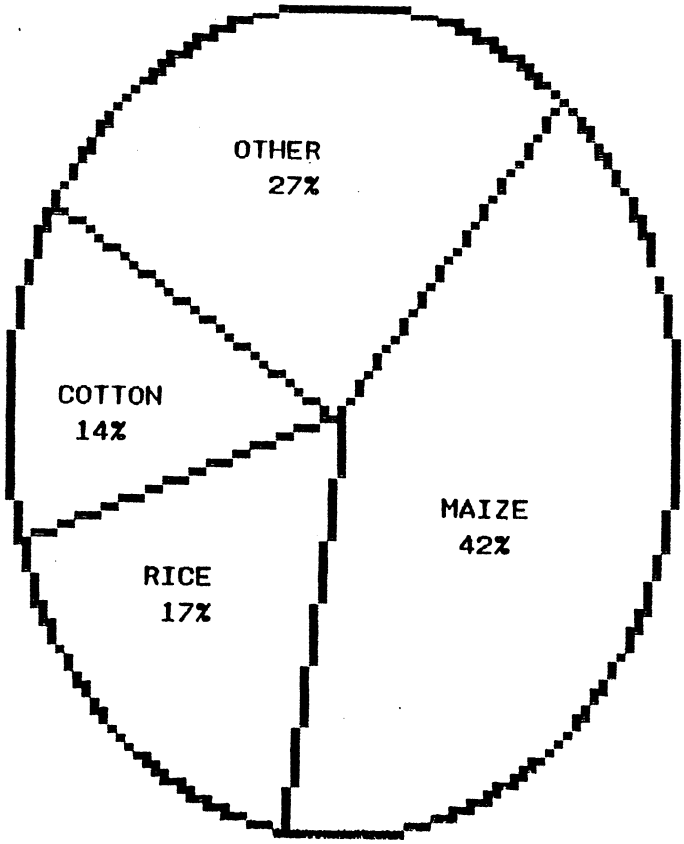


FIGURE 4:

LAND UTILIZATION BY CROP

KILOSA DISTRICT

A brief cropping calendar is provided below:

```
CROP     OPERATION OCT NOV DEC JAN FEB MAR APR MAY JUN JUL AUG SEP
-------------------------------------------------------------------
MAIZE    LAND PREP ###                            ######      ###
(SOUTHERN)PLANTING   ****                              ***
         WEEDING     +++++++++++                          ++++++++
         HARVEST   @@@@                  @@@@@@@@@@@
-------------------------------------------------------------------
MAIZE    LAND PREP ##################
(CENTRAL)PLANTING       ****************
         WEEDING           +++++++++++++++++++++
         HARVEST                            @@@@@@@@@@@@@@@@@@@@@@@@@@
-------------------------------------------------------------------
MAIZE    LAND PREP #######################
(NORTHERN) PLANTING          **************
         WEEDING             +++++++++++++++++
         HARVEST                            @@@@@@@@@@@@@@@
-------------------------------------------------------------------
COTTON   LAND PREP             #######
         PLANTING                     *****
         WEEDING                        ++++++++++++
         HARVEST                                        @@@@@@@@@@@
-------------------------------------------------------------------
RICE     LAND PREP       #####
         PLANTING            *****
         WEEDING             +++++++++++++
         HARVEST                            @@@@@@@@@@@@@
-------------------------------------------------------------------
```

As can be seen from the crop calendar the distinction among the three zones (southern, central, and northern) relates chiefly to the timing of maize production and is discussed below. In all of the areas the most important labor bottlenecks occur when all three crops require attention which is in the period from January through March. These bottlenecks are partially resolved through the hiring of labor which is the largest cash production expenditure.

Maize is the chief staple crop and dominates in terms of both land use and total crop production throughout the District. Area farm families cite self-sufficiency in maize as a primary production goal and most of them ordinarily neither sell nor buy any maize. Throughout the area addressed by the experimental program a substantial percentage of the maize fields are planted during the short rains (although since the traditional varieties require 120 days to mature they are harvested during the main rainy season). In the southern zone, the second most important maize production period is during the dry season, when maize is grown on residual moisture in low lying areas. In the northern zone, where the short rains are less reliable, a good deal of maize is in fact grown during the main rains. In the central zone there is really only one maize growing period, the short rains. Overall the survey data revealed that 90% of the maize fields are planted before January 15 in the southern and central zones and over half are planted before that date in the area to the north of Kilosa town.

Farmers in all three zones choose to plant their maize early for a number of reasons. The most important reason is that the earlier the maize is planted the earlier it can be harvested. Typically the farmers who plant in November

can begin to eat green maize in February and can harvest dried maize in March. Maize planted during the main rains will only be consumed from late May onward. Secondly, planting maize early is a risk reducing strategy since if the short rains are poor the farmers still have the opportunity to replant in time for the main rains. Thirdly, by planting maize early the farmer reduces the competition between maize and the other principal crops in the system -- rice and cotton. While the competition between maize and rice is solely in terms of labor, the competition between maize and cotton also involves land use. Of the three crops, maize is by far the most flexible in terms of timing. Whereas rice has to be planted after the rains are well established but still have a long way to go (hence a December planting date) and cotton must be planted so that it matures in dry weather (hence a February planting date), maize will produce adequately if not optimally when planted at a variety of times throughout the growing season. A final reason for the planting of maize in the short season is that the farmers thus avoid maize streak virus, a serious disease which is particularly destructive to late planted maize. Early planted maize escapes damage because the leaf hopper vector is not yet well established.

DESIGN OF THE EXPERIMENTAL PROGRAM

Initially the FSR team at Ilonga decided to focus on on-farm experiments of on the shelf technologies developed by the commodity programs. Thus timing issues were principally addressed in terms of when crops were to be grown. In the first year of the program 1984/1985 on-farm experiments were planted in the short and main rains as well as during the dry season. The results of these experiments are discussed briefly below. Relatively rapidly, however, the FSR program has moved towards the consideration of more complex timing issues both on and off the station. These issues are treated in a separate section.

INITIAL ON-FARM EXPERIMENTS

Based upon the analysis of the systems it was felt that labor bottlenecks in terms of weeding for all crops and land preparation for main season crops could be addressed through changes in crop sequencing and through increased intensification achieved by expanded intercropping. Furthermore it was felt that the National Maize Research Program had developed maize varieties (and the National Grain Legumes Program had cowpea and green gram) which would be readily accepted by farmers for both the short and main rains.

On-farm trials were planted in both the short and main rainy seasons in all three zones and in the dry season in the southern zone (these last trials are still in the field). The modifications proposed for the short rains consisted of the provision of Kito, a 90 day maize variety to be intercropped with cowpeas or green gram of very short maturity. The specific advantages to be attained are listed below:

1. The farmers would be provided with a short season maize variety which could be planted in November and harvested in February. By moving up the harvest by one month the farmers would obtain a supply of the preferred food, maize, during a period when it is ordinarily in short supply.

2. The yield performance of this short season variety would be compared

over time with full season varieties to see which performs better in terms of average yield as well as which has the lowest variability of yield.

3. The possibilities for increased intercropping, particularly with grain legumes, would be investigated based upon the recognition that Kito has a much smaller plant structure than the other common maize varieties and therefore would result in less shading. The National Grain Legumes Research Program had short maturity varieties (60 days) of both cowpeas and green gram available. varieties (60 days) are available.

4. Improved land use would be possible since an extra month of the growing season would be provided at the start of the main rains. This "head start" on the main season rains should result in increased production of cotton, maize or legumes in that season.

The researchers' expectations of the farmers evaluations of Kito were somewhat uncertain due to the lower yield potential of that variety under optimal conditions and the its relatively small cob size. Ordinarily yield and cob size are among the most important characteristics cited by farmers in rating new varieties.

The same farmers were also asked to participate in the main season experimental program. The advantages to be offered the farmer during the main rains were more straightforward. The variety to be introduced, Staha, has similar characteristics to the traditional varieties but exhibits a much higher tolerance to maize streak disease than do the existing varieties. The objective of the research program for the main rains was to demonstrate the improvement in yields which would be possible during the "optimum" maize growing period. It should be noted that in terms of yield potential Kito is assessed at 3.5 tons ha-1 and Staha at 5.0 tons ha-1.

RESULTS

A total of 34 farmers in twelve villages participated in the short season trials. In the main season it was more difficult to maintain farmer interest (they were busy with other crops) and only 15 continued to participate through to harvest time. It is instructive to compare the results as well as farmer reaction to these two sets of experiments. Although Kito performed fairly well (it yielded just over 1.5 tons ha-1 with no fertilizer) it was outyielded by traditional maize varieties by 15%. The intercropped grain legumes were in contrast devastated by elegant grasshopper attacks early in the cropping season and were largely lost. In spite of the poor main season rains (Figure 2) Staha provided a more striking contrast with the local variety control plots. It also averaged just over 1.5 tons ha-1 and outyielded the local check by more than two to one. The increase appeared to be due to better germination and greater streak tolerance.

In the light of these yield figures it might seem somewhat surprising that the farmers in all three areas were nearly unanimous in declaring themselves more interested in the Kito introduction. Their reasons were almost entirely timing related. Most of the participating farmers choose not to plant maize during the long rains (when Staha produces best) because they concentrate on cotton and rice production at that time. Even the potential for increased yields

provided by Staha may not change this pattern drastically. In contrast, the farmers recognize that the planting of Kito during the short rains permits them to better achieve their primary family production goals. First, their maize harvest is hastened to a period when family supplies are low and market prices are high. Second, family labor is freed from February onward when the rice and cotton crops require much attention. Additionally the farmers felt that Kito's shorter maturity would allow it to provide a more stable yield in years in which the short rains were poor. Thus, while the results achieved by Staha during the long rains are statistically more impressive than the Kito results, they do not represent the same sort of major advancement for the farmer's production system as a whole. Many would in fact prefer to devote their labor during the main rains to rice and cotton.

During the main rains, experimental work which may ultimately be of more interest to the farmers was initiated on the station. Currently in Kilosa District there are by-laws which prohibit the interplanting of cotton with other crops. Area farmers, however, follow a traditional system of relay cropping the cotton in the drying maize fields which is an effective mechanism of minimizing land preparation and weeding time. Because of the political sensitivity of the work these experiments were only placed on the research station. Based upon a single season's data, the results were quite promising as they showed that in intercropping situations the maize yields (using the new smaller Kito variety) can be maintained at their sole cropped levels and the cotton yields only reduced by 30%. Overall the total return per hectare is increased by 44%. From the farmer's perspective this intercrop is undoubtably quite attractive. Subsequent research will also branch out to consider to the intercropping of cotton and cowpeas in which both crops should be able to benefit from the same insecticide. Once again the impetus for initiating this trial came from observations on farmers' fields.

THE INCLUSION OF OTHER TIMING ISSUES

Based upon the credibility which the FSR program gained from the successes achieved in the initial year of experimentation, the FSR has in the current year moved towards the consideration of more complex issues. In collaboration with the commodity programs a full slate of on-station and on-farm experiments have been planned. The on-station experiments in particular provide two fundamental innovations in the way in which research has traditionally been carried out at Ilonga. First the majority of trials are what may be termed "linked trials in that the experiments consider the production on a given plot of land during both the short and long rains. Secondly many of the trials require for the first time that permanent plots be established since the effects of the treatments must be evaluated over time. Both of these innovations represent important steps toward the more accurate simulation of farmer circumstances and hence should contribute to the formulation of more acceptable recommendations. Long term experimentation is one area in which the researcher, who does not face the challenge of ensuring the year to year welfare of the family, may be in a better position to carry out far ranging experimentation than the individual farmer. The chief areas which will be considered include long term fertility studies including the influence of crop rotations (within and between years) and the possibilities of integrating green manure crops as well as soil conservation measures (principally biological ones) into the existing farming systems.

SUMMARY

Overall the farming systems program in Kilosa District has made good progress in its initial year of trials. As a result of the dramatic comparison of farmer reactions to the introduction of the Kito and Staha varieties the commodity program researchers are now much more conscious of the factors which enter into farmer evaluations of proposed new technologies. It is to be hoped that the other timing issues discussed in this paper will yield the same sort of positive reactions from farmers and researchers alike.

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POSSIBLE EXPLANATION FOR LOW ADOPTION OF SHORT KAURA OVER FARAFARA VARIETY OF SORGHUM AMONG NORTHERN NIGERIAN FARMERS[1]

J. P. Mittal

INTRODUCTION

Sorghum (*Sorghum bicolor*) occupies about 46% of the total land area devoted to cereal production in Nigeria. Its production extends as far south as latitude 6°30'N and as far north as latitude 14°N, but most of the sorghum production is in its northern parts due to the comparatively favorable climate.

Sorghum grains are used for human food and the manufacture of animal feed. Nevertheless, the stalks are also quite useful to farmers, as they are used as a local building material for fencing compound, in making thatched roofs, and in making food storage bins. In the wetter parts of the southern Guinea Savannah where yams are cultivated, the harvested stems are bent or tied in upright bundles and are used to support the growing yams (Onwueme, 1978). The dried stalks are also used as mulch on yam mounds or ridges in the northern Guinea Savannah (Ross and Walls, 1970). Where firewood is scarce, the stems are used as fuel. Sorghum stalks are also used as fuel for village-level sugar juice processing in the northern parts of Nigeria (Oke, et al., 1984).

In northern Nigeria, farmers traditionally grow Farafara variety of sorghum, which gives stalks up to 4.3 m. Recently, a high yielding variety of sorghum named Short Kaura was introduced which yields stalks up to 2.2 m. Qualitatively, the properties of grains and stalks of these varieties were quite different from each other. It was found that the high yielding variety did not become popular among Nigerian farmers despite vigorous extension efforts.

It was postulated that the farmers may be giving consideration to the properties of grains and stalks (using their sensory judgment to evaluate these properties) to select a particular variety. This study was undertaken to evaluate the engineering properties of sorghum grains and stalks based on objective tests, and to see if the variations in the properties may possibly give some clues for low adoption of Short Kaura over Farafara variety of sorghum among northern Nigerian farmers.

Engineering Properties of Grains and Stalks

A comprehensive test scheme was laid to evaluate selected engineering properties of grains and stalks obtained from two varieties of sorghum, namely: Farafara and Short Kaura.

The properties evaluated for grains were size, shape, thousand kernal weight (TKW), density, porosity, and rupture strength. The length, diameter, slenderness ratio, solid density, compressive, tensile and shear strengths, and the deflection characteristics of sorghum stalks were also

evaluated. The details of the test scheme are given in Oke, et al. (1984); Mittal, et al. (1985), and Oke, et al. (1985).

Properties of Grain

The roundness of sorghum grain ranged from 0.39 to 0.64 cm for Short Kaura and 0.42 to 0.68 cm for Farafara. The sphericity of the grain was found to be 0.62 and 0.75 cm for Short Kaura and Farafara, respectively. For the two varieties selected, the Farafara grain dimensions were always found to be higher than that of Short Kaura by about 10%. Farafara grains gave an average volume of 22.62 mm^3, while Short Kaura grain had 17.23 mm^3. The weight of grain to earhead ratio was always higher in the case of Short Kaura than Farafara, even though Farafara earheads were found to be about 25% longer than those of Short Kaura. TKW of Farafara was comparatively higher (36.39 g) than that of Short Kaura (28.20 g). Solid density of Farafara grains was 1.14 g cm^{-3}, whereas it was 1.19 g cm^{-3} for Short Kaura grains and, as expected, the porosity and bulk density of Farafara was about 2% less than Short Kaura. The rupture strength of Short Kaura grain was found to be 7.4 N at 23% moisture content, whereas for Farafara it was 14.7 N at 27% moisture content (implying that comparatively more energy would be needed for the size reduction operation of Farafara grain [Oke, et al., 1985]). The color of Farafara grain was white, whereas it was yellow in the case of Short Kaura grains.

Properties of Stalk

The average overall and internodal lengths of the stalk obtained from Short Kaura and Farafara are given in Table 1. It may be seen that internodal lengths of both varieties are randomly distributed. There was more uniformity in the internode distribution of Farafara than that of Short Kaura, but the number of nodes were about the same in both varieties. The average diameter of Short Kaura stalk was 2.61 cm, whereas Farafara stalks had a diameter of 2.16 cm. Under one end fixed and the other end with free conditions (as in a standing plant), the slenderness ratio (the ratio between the length or height of the standing plant and the radius of gyration of the stalk) was found to be varying, from 126 to 170 cm for Short Kaura and from 345 to 390 cm for Farafara stalks. Solid density of Farafara stalks for the portion near the roots was 0.856 g cm^{-3}, whereas for the same portion it was observed to be 0.783 g cm^{-3} for Short Kaura. The tensile, compressive and shear strengths of Farafara stalks were higher than Short Kaura, as reported by Oke, et al. (1984), and Mittal, et al. (1985).

Possible Reasons for Low Adoption of Short Kaura over Farafara

The reasons for low adoption of Short Kaura over Farafara among Nigerian farmers may be classified into two categories: (1) due to properties of grain, and (2) due to properties of stalk.

The shape of Farafara grains is more round and uniform than the Short Kaura grains. Also, the size of Farafara grain is bigger than Short Kaura grain. The color of Short Kaura grain is yellow, while that of Farafara grain is white. The TKW of Farafara grains is higher than Short Kaura

grains. The Farafara grains have higher rupture strength than Short Kaura (in Nigerian dishes, hard sorghum grains are preferred over soft grains when they are not converted into flour). All these properties of the grains are desired among Nigerian consumers. Thus, the properties of Farafara grains have a comparative edge over the high yield of Short Kaura (yield of Farafara is 2.3 t ha^{-1}, whereas of Short Kaura it is 2.8 t ha^{-1} [Obilana, 1981]).

The resistance by the farmers to the Short Kaura variety (despite its better grain yield) may be due to its shorter stalk length (almost half that of Farafara), which is a limitation to its present usage as a roofing and fencing material since both operations require longer stalks. The uniformity of the Farafara internode length is also of help in making roof and fence matrix. However, the Short Kaura variety will stand better as a column (since it has a lower slenderness ratio) in local food storage bins and when used to support vines of crops such as yams. The strength characteristics of stalks derived from Farafara plants are higher than those of Short Kaura stalks. This may be another reason why farmers are reluctant to adopt the Short Kaura variety.

The farming systems researchers should, therefore, introduce some other building material, like kenaf, to reduce dependence on sorghum stalks, as it may be difficult for the breeder to develop tall, high-yielding varieties because of increased lodging potential.

Footnote

[1] Work was done in the Department of Agricultural Engineering, PMB 1044, Ahmadu Bello University, Zaria, Nigeria.

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Table 1. Average overall and internodal lengths of Farafara and Short Kaura stalks.*

Nodal Number (From the Bottom)	Average Internodal Length in cm		Percentage of the Total Length	
	Farafara	Short Kaura	Farafara	Short Kaura
1.	8.8	2.8	2.12	1.30
2.	11.0	4.1	2.65	1.90
3.	14.1	4.8	3.40	2.23
4.	15.9	5.3	3.83	2.46
5.	16.9	6.3	4.07	2.92
6.	17.8	7.3	4.29	3.39
7.	18.0	8.3	4.34	3.85
8.	16.9	8.4	4.07	3.90
9.	17.6	9.3	4.24	4.32
10.	18.4	9.5	4.43	4.41
11.	19.0	10.4	4.58	4.83
12.	18.9	9.0	4.55	4.18
13.	18.3	8.9	4.41	4.13
14.	19.8	9.1	4.77	4.22
15.	21.0	9.4	5.06	4.36
16.	21.4	9.3	5.16	4.32
17.	22.5	8.4	5.42	3.90
18.	22.1	7.9	5.33	3.67
19.	20.3	7.7	4.89	3.57
20.	21.8	6.8	5.25	3.16
21.	23.5	5.6	5.66	2.60
22.	31.0	27.0	7.48	12.53
23.	--	29.8	--	13.85
Total	415.0	215.4	100	100
Range	8.8-31.0	2.8-29.8	2.12-7.48	1.30-13.85

* Average of 8 samples

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